USE OF SALINE GROUNDWATER FOR CROP PRODUCTION ON SALT AFFECTED SOIL

By

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ABSTRACT:-The study was carried out on saline-sodic, non-gypsiferous and silty clay loam soil adjacent to Shorkot city. Ten treatments were tested in Completely Randomized Block Design. The treatments included:- **T_1-** Irrigation with canal water-No amendment (control), **T_2** -Irrigation with Canal Water + Gypsum @ 25 % GR of soil, **T_3** - Irrigation with Canal Water + FYM @ 25 tons ha^{-1}, **T_4** - Irrigation with Canal Water + Press mud @ 10 tons ha^{-1}, **T_5 -** Irrigation with Canal Water + Deep Ploughing, **T_6** - Irrigation with Tubewell Water-No-amendment, **T_7** - Irrigation with Tubewell Water + Gypsum @ 25 % GR of soil, **T_8** - Irrigation with Tubewell Water + FYM @ 25 tons ha^{-1}, **T_9** - Irrigation with Tubewell Water + Press mud @ 10 tons ha^{-1}, **T_{10}** - Irrigation with Tubewell Water + Deep Ploughing. The initial EC_e and SAR of 0-30 cm soil ranged within 6.3 to 16.4 (dS m^{-1}) and 7.8 to 19.6 (mmol $L^{-1})^{1/2}$ respectively. Kharif fodder - wheat crop rotation was followed. Tubewell water having EC 4.03 (dS m^{-1}), SAR 8.74 (mmol $L^{-1})^{1/2}$ and RSC almost nil was applied to the crops. The EC_e of 0-30 cm soil depth decreased at the end of the study in all the treatments. Maximum reduction by 58 percent was recorded under the treatment where Pressmud @ 10 tons ha^{-1} was applied with canal water irrigation. SAR of the soil decreased at the end of the study in all the treatments except T_6 under no amendment application. Maximum decrease by 56 percent was observed where Pressmud @ 10 tons ha^{-1} was applied with canal water irrigation. The highest kharif fodder yield of 18621 kg ha^{-1} was observed with Pressmud application @ 10 tons ha^{-1} with canal water irrigation. The highest wheat grain yield of 2817 Kg ha^{-1} was recorded with Pressmud @ 10 tons ha^{-1} with canal water irrigation. Pressmud application @ 10 tons ha^{-1} proved to be the best option for soil improvement and crop production. Use of poor quality groundwater with no-amendment reduced soil salinity to negligible extent, increased soil sodicity and produced lower crop yields. However, poor quality water can be used for sustaining agriculture in combination with amendments in the soil. Saline groundwater irrigation helped in mitigating crop water shortage, cropping on sustainable basis and lowering watertable at farm level and improvement of soil environment by reduction in upward movement of salts and crop production on sustainable basis on salt-affected soil.

Key words: Use , Saline Groundwater, Crop Production, Salt-Affected Soil

1. INTRODUCTION

Pakistan has an extensive irrigation system in the country. Canal seepage, defective conveyance and inefficient irrigation methods have created the problem of waterlogging and salinity. Drainage provision to the irrigated land helps in mitigating the adversities of these two serious problems. Consequently, a dire need arises to adopt appropriate strategies to provide drainage facilities in order to provide aerobic conditions for crop growth. Vertical drainage can be helpful at local level in controlling waterlogging to safer level. Lowering of water table indirectly reduces salt accumulation in the crop root zone area by hindering the access of salts in the upper soil horizon. The present canal supplies are not sufficient to meet with the crop water requirements. Exploitation of the groundwater reserves can be an alternative to supplement crop water shortage. About 50% of the groundwater reserves are fit for irrigation whereas the remaining 50% require amending prior its irrigation to the crops. Application of amendments in the soil with tubewell irrigation can be helpful in growing salt-tolerant crop cultivars on salt-affected soil in order to mitigate the enhanced food and fiber requirement of the

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increased population. Withdrawal of groundwater helps in lowering depth to water table, reduces upward salt movement, provides aerobic conditions for sustaining agriculture and helps in improving soil environment by controlling soil salinization/sodication.

2. MATERIAL AND METHODS

The study was initiated in the suburbs of Shorkot Tehsil of Distt. Jhang during July 2005.
Salt-affected field, measuring about one hectare, situated on Shorkot Cantt. Road, about 3-kilometers away from Shorkot city was selected for this study. Soil samples from 0-30, 30-60 and 60-90 cm depth were collected in the beginning of the experiment to determine soil texture and salinity/sodicity status of the selected field (Table 1 and 2). Subsequent soil sampling was carried out after harvesting of each Kharif and Rabi crop. Kharif fodder and wheat crops were sown in Completely Randomized Block Design with three repeats. Recommended cultural practices were followed. The treatments included:- **T_1-** Irrigation with canal water-No amendment (control), **T_2** -Irrigation with Canal Water + Gypsum @ 25 % SGR, **T_3** - Irrigation with Canal Water + FYM @ 25 tons ha^{-1}, **T_4** - Irrigation with Canal Water + Press mud @ 10 tons ha^{-1}, **T_5 -** Irrigation with Canal Water + Deep Ploughing, **T_6** - Irrigation with Tubewell Water-No-amendment, **T_7** - Irrigation with Tubewell Water + Gypsum @ 25 % SGR, **T_8** - Irrigation with Tubewell Water + FYM @ 25 tons ha^{-1}, **T_9** - Irrigation with Tubewell Water + Press mud @ 10 tons ha^{-1}, **T_{10}** - Irrigation with Tubewell Water + Deep Ploughing. Tubewell water having EC 4.03 (dS m^{-1}), SAR 8.74 (mmol $L^{-1})^{1/2}$ and RSC almost nil was applied for irrigation to the crops. The crop yields were estimated on the whole plot basis and converted as kg ha^{-1}. The study continued from July 2005 to June 2008 over a span of three years.

Table 1 Physical Condition of the Study Site

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Textural Class
0-30	14	52	34	Silty Clay Loam
30-60	12	49	39	Silty Clay Loam
60-90	13	41	46	Silty Clay Loam

Table 2 Baseline Chemical Analysis of the Study Site

Depth (cm)	pH	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$
0-30	8.5	11.6	19.6
30-60	8.4	6.4	8.6
60-90	8.4	6.3	7.8

3. RESULTS AND DISCUSSION

The effect of different treatments on soil salinity/sodicity build-up and crop yields is discussed as under:-

3.1 Soil Salinity (EC_e dS m^{-1})

The study continued from July 2005 to June 2008 over a span of three years comprising six crop seasons. EC_e reduced in 0-30 cm soil depth in all the treatments. Maximum reduction by 58 % was observed in T_4, where Pressmud was applied @ 10 tons per hectare with canal water irrigation. Minimum reduction by 9 percent was recorded under T_6, Deep Ploughing with tubewell water irrigation. All the other treatments fell within these two ranges. Canal water irrigation depicted more decrease in soil EC_e than tubewell water irrigation. Application of amendments and gypsum facilitated in reducing soil EC_e compared to the treatments where amendment was not applied with both the sources of irrigation (Table 3). Ameliorants reduced soil EC_e. Higher reduction was observed under Pressmud treatment. The results are in agreement with the findings of Niazi et al. 2001.

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Table 3 Effect of Different Treatments on EC_e of 0-30 cm Soil Depth (dS m^{-1})

Treatments	Pre Kharif 2005 S_1	Post Kharif 2008 S_7	Percent Dec Over Initial
T_1 Canal Water (Control)	18.6	13.5	-27
T_2 Gyp @ 25 % SGR	16.5	10.7	-35
T_3 FYM @ 25 tons ha^{-1}	16.6	8.3	-50
T_4 Pressmud@10 tons ha^{-1}	14.0	5.9	-58
T_5 Deep Ploughing	18.1	15.7	-13
T_6 Tubewell Water	12.4	11.3	-9
T_7 Gyp @ 25 % SGR	24.6	16.8	-32
T_8 FYM@ 25 tons ha^{-1}	10.5	6.8	-35
T_9 Pressmud @10 tons ha^{-1}	15.3	7.2	-53
T_{10} Deep Ploughing	19.1	17.2	-10

3.2 Soil Sodicity (SAR mmol $L^{-1})^{1/2}$

Sodicity of 0-30 cm soil decreased to the maximum extent by 56% in T_4, where Pressmud was applied @ 10 tons ha^{-1} with canal water irrigation. Conversely tubewell water + Pressmud application @ 10 tons ha^{-1} depicted minimum reduction by 19% over initial value. Reduction in soil SAR in other treatments ranged within these two limits. SAR reduced under all the treatments except T_6, where amendment was not applied, depicted 9% increase over initial value. Canal water reduced soil SAR more than tubewell water application. Higher reduction rate was observed under Pressmud treatment (Figure 1). Generally reduction rate decreased with increase in depth. Application of amendments desodicated the soil. The results are in consistent with the work of Hyas et al., 1997, Wahid et al., 1998 and Sahin et al. 2002.

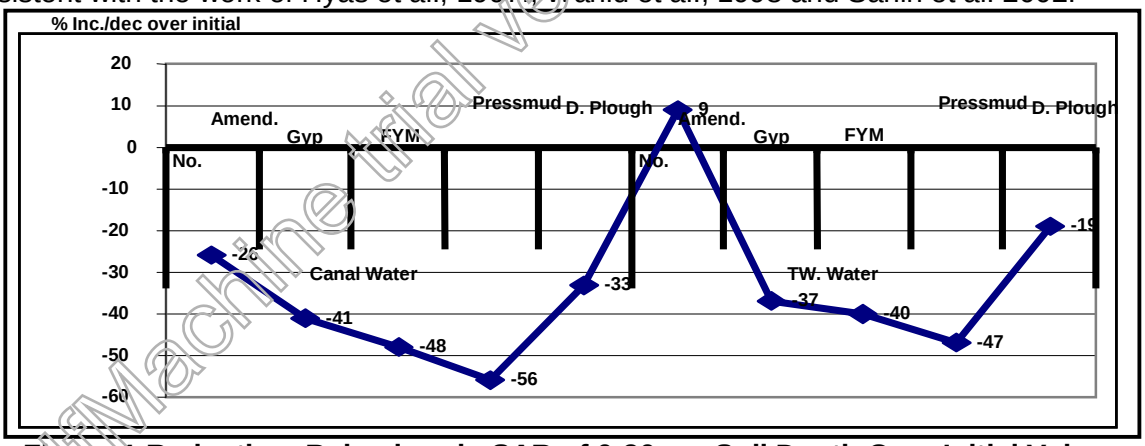


Figure 1 Reduction Behaviour in SAR of 0-30 cm Soil Depth Over Initial Values

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3.3 Crop Yields

Kharif fodder and wheat grain yields were estimated on the whole plot basis and were calculated as kg ha^{-1}.

3.3.1 Kharif Fodder Yield

Maximum average kharif fodder yield of 18621 Kg ha^{-1} was obtained where Pressmud @ 10 tons ha^{-1} was applied with canal water irrigation being 57 percent higher than control. Minimum kharif fodder yield of 10264 Kg ha^{-1} was recorded where no amendment with tubewell water was applied. Gypsum application @ 25% SGR with canal water irrigation gave 25% higher kharif fodder yield than control whereas tubewell water irrigation depicted 21% higher yield than control treatment. Similarly farmyard manure application with canal water irrigation indicated 41 percent higher yield than control whereas under the same treatment 33 percent higher yield was obtained with tubewell water irrigation. Deep ploughing did not depict satisfactory impact on kharif fodder yield (Table 4 and Figure 2). Amendments application increased kharif fodder

yield. The results are in agreement with the findings of Haider et al. 1976, Jerald et al. 1977, Ali et al. 1978, Tripathi and Pal, 1980, Yadav 1980, Ghafoor et al. 1998 and Chaudhry et al. 2004.

Table 4 Effect of Different Treatments on Kharif Fodder Yield

(kg ha^{-1})

Treatments		Period					% Inc/Dec. over Control
		2005	2006	2007	2008	Average Yield	
Canal Water	T_1 No amendment	10734	13166	6422	17095	11854	-
	T_2 Gypsum @ 25 % SGR	14668	16821	8084	19900	14868	+25
	T_3 FYM @ 25 tons ha^{-1}	16915	16207	12391	21256	16692	+41
	T_4 Pressmud @ 10 tons ha^{-1}	17422	18783	15919	22341	18621	+57
	T_5 Deep ploughing	12000	13783	6512	18422	12694	+7
Tubewell Water	T_6 No amendment	9196	11224	5879	14758	10264	-13
	T_7 Gypsum @ 25 % SGR	13000	14905	10763	18924	14349	+21
	T_8 FYM @ 25 tons ha^{-1}	15500	16332	11397	19643	15718	+33
	T_9 Pressmud @ 10 tons ha^{-1}	15668	16688	17276	21527	17789	+50
	T_{10} Deep Ploughing	10300	12046	6331	15578	11064	-6

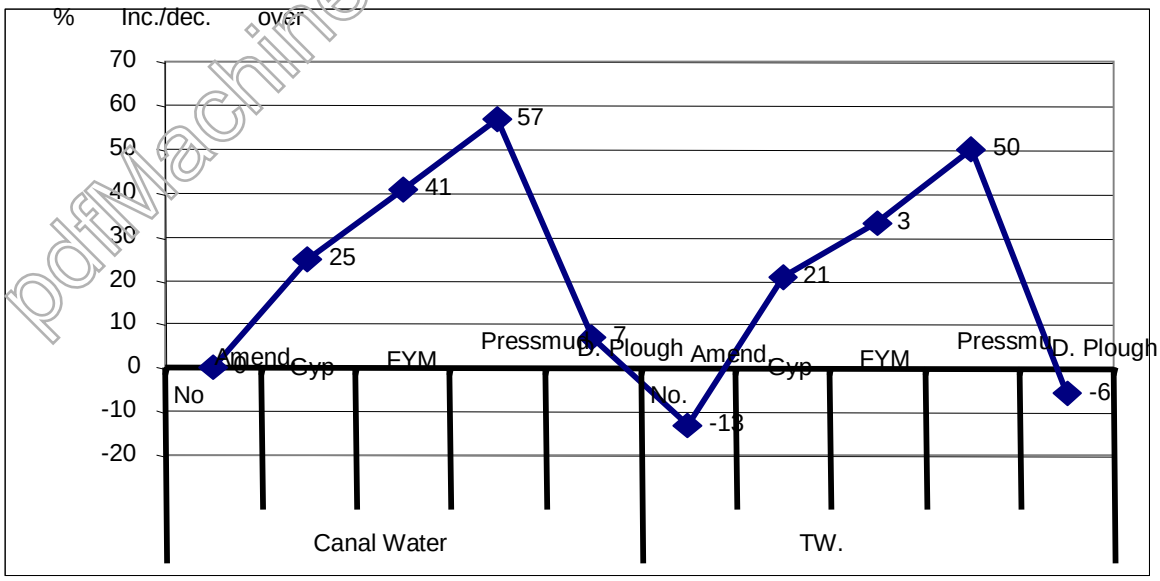


Figure 2 Kharif Fodder Yield Comparison With Control Treatment

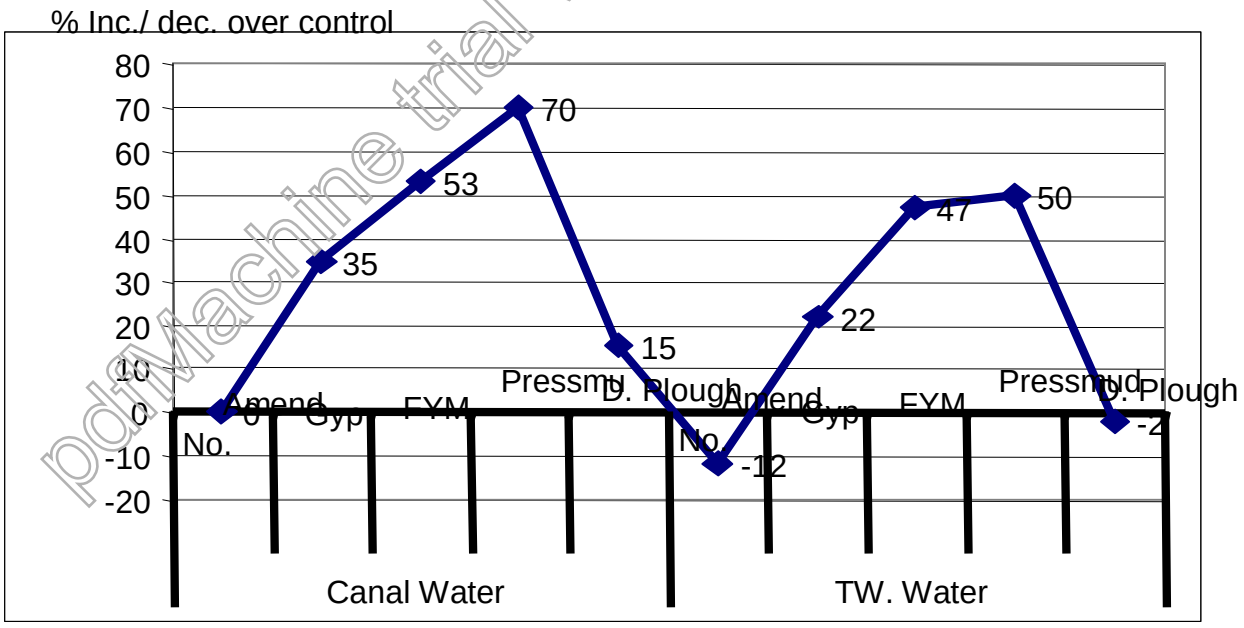
3.3.2 Wheat Grain Yield

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Maximum average wheat grain yield of 2817 Kg ha^{-1} was obtained where Pressmud @ 10 tons ha^{-1} was applied with canal water irrigation. This yield level excelled by 70 percent over control. Treatment T_6 where amendment was not applied, indicated the lowest yield of 1513 Kg ha^{-1} with tubewell water irrigation. Gypsum application @ 25% SGR with canal water irrigation gave the highest yield amongst the treatments except Pressmud application @ 10 tons ha^{-1} (Table 5 and Figure 3). Application of ameliorants increased wheat grain yield. The results are in agreement with the findings of Oster, 1982 and Swarup. 1994.

Table 5 Effect of Different Treatments on Wheat Grain Yield (Kg ha^{-1})

Treatments		Period				% Inc/ Dec over control
		2005-06	2006-07	2007-08	Average Yield	
Canal	T_1-No amendment (control)	1779	1990	1345	1705	-
	T_2-Gypsum @ 25% SGR	2263	2544	1563	2123	+35
	T_3-FYM @ 25 tons ha^{-1}	2061	2885	1993	2312	+53
	T_4- Pressmud @ 10 tons ha^{-1}	2379	4032	2040	2817	+70
	T_5-Deep ploughing	1890	2442	1452	1928	+15
Tubewell	T_6-No amendment	1700	1628	1210	1513	-12
	T_7-Gypsum @ 25%SGR	1950	2653	1235	1946	+22
	T_8-FYM @ 25 tons ha^{-1}	2010	3528	1270	2269	+47
	T_9-Pressmud @ 10 tons ha^{-1}	2053	3618	1756	2476	+50
	T_{10}-Deep Ploughing	1730	1990	1307	1692	-2



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Figure 3 Wheat Grain Yield Comparison With Control Treatment

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

- Pressmud treatment with canal water irrigation reduced EC_e of 0-30 cm soil to the maximum extent amongst the treatments.

- Impact of pressmud application on soil SAR was similar to EC_e.

- Saline groundwater irrigation helped in supplementing crop water requirement and producing relatively sustainable crop yields.

- Pressmud application gave higher Kharif fodder and wheat grain yield than other treatments.

4.2 RECOMMENDATIONS

- Saline ground water can be used for sustaining agriculture in combination with amendments like Pressmud @ 10 tons ha^{-1} & FYM @ 25 tons ha^{-1}.

- Continuous use of pure saline ground water be avoided.

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Message from
Engr. Husnain Ahmad
President
Pakistan Engineering Congress

Dear Members!

In the first instance, please accept my sincerest gratitude for your unflinching support extended to me in the conduct of the day to day affairs of the congress and above all for your participation in its professional activities. The congress journal completed 50-years of its publication in December 2009. Hence, the present issue for the quarter October – December 2009 is the "Golden Jubilee" edition. It is studded with numerous articles of eminent scholars on myriad issues.

The year 2009 has also been a year of high achievements. The congress headquarter, the library of the congress, Mashhadi Hall (i.e. the congress auditorium) as well as the overall edifice of congress building have undergone construction and major modernization to enable more effective pursuit of the objectives of the congress enshrined in its constitution as well installation of a security apparatus to ensure safety of life & property of inmates of the premises.

I also wish to share with you, the landmark achievements of the Pakistan delegation that attended the **60th IEC Meeting and 5th Asian Regional Conference, New Delhi, India from 6-11 December 2009 (included 2-members of the congress) led by the undersigned in keeping with the GOP decision – a feather in the cap of the congress.**

Participation of the Pakistan delegation, compared to other delegations attending the occasion was considered as the most effectual and exceptionally commendable, not only because of its active participation in each and every session of Working Groups (WG's), Task Forces, and various Committee meeting(s) but also for its valuable contributions. It was the most sought after delegation and especially came into the glare of publicity on.

- Prof. Dr Rai Niaz Ahmad's *'Wheat Bed Planter'* won him the WatSave Technology Award 2009. The bed planting machine develops two beds and three furrows in single operation. This machine is the result of Dr. Rai's individual research spanning over more than a decade.

- President, Pakistan Engineering Congress & head of the delegation's nomination as member for "**Permanent Committee for Technical Activities**" (PCTA).

- In addition to PCTA membership, the Pakistan delegation comprising of 6-members bagged:

    - 5-Nominations on Working Groups

    - 1-Nomination on Task Force

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The Pakistani contingent being in the forefront of the mega event, won appreciation of the World, by receiving great recognition through its achievements. It was a remarkably laudable feat of the professionals from Pakistan, to be a highlighted part of such prestigious event, building the esteem and honor of their Country.

Another worthwhile improvement is the addition of an “Index” of the papers published in the congress journal overtime, a treasure trove of 617 papers. There are some issues that are not forthcoming from the records (listed at page 17). If any of the missing issues are available with you, please help provide these to congress secretariat for re-production & return of the original with thanks.

With profound regards,

Yours sincerely



(Engr. Husnain Ahmad)
President

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Message from
Engr. Husnain Ahmad
President
Pakistan Engineering Congress

Dear Members

Assalam-o-Alaikum

It gives me immense joy to inform your kindself that the Quarterly Journal of Pakistan Engineering Congress “Engineering News” has completed 50 Years of its publication. It includes 2 Sections one devoted to news pertaining to engineering matters and the second section contains Technical Papers. Most of the copies of the Journal have been brought on Web-site (missing one’s are being traced). We have been facing dearth of Papers which is mainly responsible for issue delays. Nevertheless, it should not deter us from compiling a Golden Jubilee Edition. However, the purpose cannot be fulfilled without your co-operation, support and advice. The congress is indebted for your participation and patronage of its professional activities. It would be highly appreciated if a paper on any theme of your own choice for inclusion in this memorable volume is furnished at the earliest.

Yours sincerely



(Engr. Husnain Ahmad)
President

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PAKISTAN ENGINEERING CONGRESS

Symposium

on

"Genesis of Power Crisis & its Management in Pakistan"

ADDRESS BY
Engr. Husnain Ahmad
President
Pakistan Engineering Congress

Chief Guest of the Symposium, the Honourable Syed Khursheed Ahmad Shah Sahib, Minister for Labour and Manpower, Respected Scholars, Executive Council Members, Distinguished Guests, Fellow Engineers,

Ladies & Gentlemen

Assalam-o-Alaikum

It is my profound privilege to welcome you all on such a critical and burning topic of this very moment. The ever increasing importance of the topic becomes much more relevant and amplified with the present day situation of power requirements vis-à-vis its availability in the country. The heat of power deficit is being felt by the entire Pakistani nation especially by the sector contributing in the economic development so very profusely.

Energy is the life line of economic development but unfortunately Pakistan lacks integrated National Energy Security Plan for the 21st century and, therefore, the country is faced with a crippling power shortage to the tune of almost 1890 M.W. The peak demand is around 19600 M.W vis-à-vis supply of 17710 M.W necessitating Electricity outages of 10-12 hours daily. Non-availability of power & the frequent interruptions have wreaked the economic fabric of the country culminating in:

- De-stabilized the entire economic structure of the country.
- Given a stunning blow to Agriculture sector for acute shortage of water supply & non-availability of power for tubewells.
- Industrial Production has suffered enormous set-back. Textile, Garment and host of other Industries are at a stand still.
- Un-employment Conditions have further worsened exacerbating law and order problems etc.
- Large Scale Manufacturing (LSM) has shown 7.7% negative growth.
- GDP growth is sliding down (will be only 2%).

The ironical position is that the devastating situation is not a bolt from the Blue but a simmering sore since the last about a decade. The planners could not be oblivious that there is massive influx of Electric gadgets and the demand for electricity was accelerating at an annual rate of 8% – 10% an increase from 15500 MW in 2005 to 21500 MW in 2010 and that the industrial and agricultural advancement needs steady & cheap Electric supply. However, there was abject disregard for increasing the power potential of the country.

Infact, it tantamounts to criminal neglect and is full of ominous portents coming as it is at a time of worst global economic recession.

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The abysmal lack of planning has been aptly described by Mr. Shahid Javed Burki a noted economist:

"Public Policy comes to the front burner only when there is a real crises on the supply side – when serious shortages have appeared in the power sector; when oil prices suddenly go up; when natural gas, once considered to be an abundant resource, also experiences supply shortages".

Ladies and Gentlemen
Looking at the situation in a bit of details reveals that Hydel Generation in 2004 was 6459 M.W & is almost the same now a bizarre situation. The Country boasts off Hydel Potential of more than 20,000 to 25000 M.W (13981 M.W alone in upper Indus Basin as can be seen as follows).

Upper Indus Basin Potential of Hydropower Schemes

Rank	Scheme	River	Power (MW)
1	Dasu	Indus	3700
2	Bunji	Indus	4710
3	Thakot	Indus	1043
4	Patan	Indus	1172
5	Rakhiot	Indus	670
6	Yulbo	Indus	710
7	Kalangai	Swat	256
8	Kohala	Jhelum	740
9	Munda	Swat	740
10	Karot	Jhelum	240
		Grand Total:	13981

Here it would not be out of place to look at the figures of Dams of more than 15-feet height in some neighboring countries, which are as shown below:

Sr. No	Country	Number of Dams Constructed upto December, 2008
1.	China	26000
2.	India	4050
3.	Turkey	591
4.	Iran	310
5.	Pakistan	71

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Kala Bagh Dam
Kala-Bagh Dam had a storage capacity of 6.1 MAF & Electricity Generation Potential of 2400 M.W initially & ultimately 3600 M.W. However, the Dam was not constructed and 3-decades lost in Political wrangling of a purely Engineering issue and in the meantime 40-45 MAF water flowed un-tapped in the sea.

Diamber Basha-Dam
The Dam will have a storage potential of 8.1 MAF & Electricity Generation potential of 4500 MW. However, it was kept on back burner for 3-decades. It has been taken-up belatedly and now we would have to wait upto 2019 to eke-out any benefits out of it.

Neelum Jhelum Project
It is run off River Project with Electricity Generation potential of 969 M.W but we will have to wait at least upto 2016 before it comes in operation & starts giving benefits.

Also given below is the potential of Hydel / Thermal & IPP's Projects in pipe-line & likely to come into operation in the year 2009 to 2011.

	Year 2009	Year 2010	Year 2011
Hydel	-	298	121
Thermal	-	-	1701
PEPCO	-	-	-
Independent Power Produces (IPP's)	2277	200	-
Total	**2277**	**498**	**1822**

In the Presence of abundant Hydro-Electric Potential and not constructing any large-Dam in the last 3-decades to provide cheap Electricity for Industrial & Agricultural advancement, saving precious Foreign Exchange used on import of Fuels for Thermal Generation shows intellectual bankruptcy (in planning) and all this has happened when the storage capacity of Mangla & Tarbela Dams has been reduced by almost 28% due to Silt, when enough water is not available for the crops, when sub-soil aquifer has dropped to 300-400 feet due to heavy Tube-well pumping & above all when India is building scores of small Dams on Indus and Chenab to deprive us of the invaluable Water Resources. It is high-time that Political wrangling & deplorable lethargy in planning are set-a-side & immediate work is started on the following Hydel Projects.

- Kala-Bagh 6.1 MAF
- Akhori 7.6 MAF
- Skardu 2.0 MAF

In addition, Small Dams need to be constructed at all available sites. Rain Water & Water of Hill-Torrents particularly in the area of Koh Sulaiman to manage it profitably & to minimize the devastation of floods due to heavy rains.

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Thermal Generation

Thermal Generation in Public sector was 11234 M.W in 2004 and remains almost the same without any significant increase till to-date. Position of Thermal Generation in private sector (IPP's) was 6070 M.W in 2004 & is now 6227 M.W.

The dismal lack of planning in Thermal Generation is nakedly glaring. Huge foreign exchange earnings have gone down the drains in import of furnace oil / other fuels as well as Gas Resources of the country depleted to dangerous levels. This has happened when the country has been endowed by nature with Coal Resources to the tune of staggering 185175 Million Tons as given below:

- Sindh 184623 Tons
- Punjab 235
- Baloochistan 217
- NWFP 91
- AJK 9

185175

Coal contributes to 38% of World's Electricity supply & 23% of global primary Energy needs. Coal contributes 16% of Energy supply in U.K, in China 67%, Canada 24%, USA 23%, India 55%, whereas, in Pakistan the contribution of coal is limited to only 7%.

- Natural Gas 48 (Percent)
- Thermal 30
- Hydro 13
- Coal 7
- Nuclear 2

100

It may also be noted that unlike Pakistan, where contribution of the coal remains minimal, fast growing economies are making full use of their Coal resources.

Had sanity prevailed with our Planners, Economists and those at the helm of affairs of the Country and the more than abundant Coal resources of the Country had been profitably exploited.

- ! There would not have been any shortage in the Electricity Supply & no recourse to electricity outages.
- ! It would have ushered a boom in the economic development of the Country & valuable foreign exchange earnings saved & channelized in creation & Modernization of Industrial Machinery.
- ! Opened-up employment opportunities & Poverty alleviation

It is imperative that Power Generation Projects based on Coal are launched with minimum possible delay & in this connection use of clean Gas Technology formulated in USA may also be used as far as economically feasible.

Nuclear Energy

Nuclear Energy Contributes immensely in the economy of Advanced Countries as would be seen by the following table:

Sr. No	Country	Share in Total Generation %
1.	U.S.A	19.4
2.	France	76.8
3.	U.K	15.1
4.	China	1.9
5	India	2.5
6.	Germany	25.9

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We have 2-Nuclear Power Plants "Karachi Nuclear Power Plant" (KANUPP) & "Chashma Nuclear Power Plant", and a 3rd Plant is under construction.

Nuclear Energy contributes only 2% of supply mix (400 MW). It is envisaged to raise the out-put to 4000 MW by 2030. In France almost 77% of energy is Nuclear energy. Infact, as per some specialists it is the most reliable source of energy supply especially in Fuel starved countries.

Renewable Energy Resources

Pakistan is blessed with abundantly available and inexhaustible Renewable Energy (RE) resources, which if tapped effectively can play a considerable role in contributing towards energy security and energy independence of the country. Given the current global energy scenario in general and Pakistan's energy scenario in particular, the adoption and deployment of ARE technologies makes perfect sense as it inherently favours indigenous, inexhaustible energy resources which also happen to be efficient options by default. This is also in line with the objective of the Government of Pakistan to develop RE technologies in the country so that RE has a share of at least 7.4% of the overall energy mix by the year 2030.

Another unique feature associated with the deployment of ARE technologies is the positive and various direct & indirect impacts it has on poverty alleviation and accruing social benefits. These technologies can be easily deployed in areas where conventional grid electricity cannot have access and entry due to technical and / or economic reasons. The lowest strata of the society can thus benefit from ARE technologies thereby improving the livelihood and quality of life; meaning ARE technologies can play an effective role for meeting the Millennium Development Goals (MDGs) as well.

It is encouraging to note that Renewable Energy technologies have reached a stage where they can effectively play their part in tackling the current energy crisis we face today. Wind energy projects are a commercially viable reality. Construction of Pakistan's first ever wind energy project of commercial scale is hopefully the first drop of water that will eventually transform into an ocean. However the Government must continue its efforts to utilize the immense wind potential available throughout the country and should not limit itself to Gharo-Keti Bandar wind corridor alone.

Approximately 73900 M.W of Electricity is being generated through Wind-Power the world over especially in the following Countries while Pakistan has recently established a project of Wind power of 50 MW in Thatta:

Sr. No	Country	Electricity Generation Wind-Power (M.W)
1.	Germany	18000
2.	Spain	8000
3.	U.S.A	7000
4	Pakistan	50

The Government should also announce incentives for the use of Solar Energy which has extremely broad-ranging applications; not just in the electricity sector but also gas sector. Shifting to Solar Water Heating can result in considerable gas savings, ranging in excess of 100 Million MMBTU annually. All new public and street lighting should only be Solar based in future. Domestic users should also be encouraged to meet a portion of their energy needs through Solar Energy. Net metering is an established, tried and tested incentive provided for use of Solar Energy throughout the world and should also be employed in Pakistan.

Alternative Energy is not just limited to wind and solar; alternative fuels also form a major portion of Alternative & Renewable Energy sector and should be encouraged as such. Government of Pakistan has announced its targets for replacing diesel with Biodiesel, which is a welcome start. But it must be realized that Biodiesel is perhaps the most challenging and complex sub-sector of the Alternative Energy Sector. The issue of food security can cause great concern and must be dealt with in an appropriate manner. Similarly selection of land for energy plantations also needs to be restricted to waste, marginal lands. Success of National Biodiesel Programme will not only reduce our dependence on foreign oil imports, it will also bring about an upturn into the quality of lives of the under-privileged farming communities and generate significant economic activity. The Government must show its resolve in supporting AEDB's initiatives.

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Suggestions

1. Experts have envisioned that the country should plan a "Capacity" generation increase of 3000 to 4000 M.W every year which would need long term planning on pragmatic basis.

2. Pakistan ought to go all-out for construction of Mega Dams for conservation of Water & Generation of cheap Electricity. However, it will be unwise to rely on Hydro-Electricity alone as it could suffer due to droughts.

3. Maximum utilization of coal resources to

    - Curtail Fuel imports
    - Open-up employment opportunities & to meet "**Capacity"** Shortage.

4. Leap-Frog in the domain of Nuclear Energy as the existing 2-Plants have already completed design life of 30 years.

5. Build Big Refineries to plug “Fuel” shortage & to obtain Petroleum By-Products such as Diesel etc.

6. Maximum utilization of Bio-Fuels “Wind Energy” & “Solar Energy”.

7. All-out efforts to conserve energy by encouraging installation of savers, curtailing un-necessary shop illuminations.

8. Import of Gas from Iran & Central Asian countries & storage of Gas.

9. Private Sector especially Foreign Investment in Hydel Projects may be invited as well as facilitated.

10. In the Short-Term LNG Imports may be resorted to.

Ladies and Gentlemen

I would like to conclude here with a hope that this symposium shall not only contribute positively towards evolving a policy for combating the issue of power deficit in Pakistan but shall go a long way towards defining the direction for the decision makers. I also believe it is already late and let us act now before it gets too late. I earnestly urge that putting political wrangling aside and keeping national interest supreme, on an issue of a purely technical nature we need to pay heed to the advice of technical experts and professionals for our economic growth and the national survival. I thank you all for being with us here today and also for giving me a very patient hearing.

“PAKISTAN PAINDABAD”

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SHALLOW GROUNDWATER QUALITY OF UN-COMMANDED AREAS OF PUNJAB DOABS

By

Abdul Hameed and Abdul Majeed *

ABSTRACT

Pakistan is an agricultural country and agriculture is the mainstay of its economy. Due to limited surface irrigation supplies, groundwater is extensively being exploited and utilized to meet the crop water requirements.

Scarps Monitoring Organization being the main groundwater investigating agency carried out water quality monitoring under NDP to assess the groundwater quality status of un-commanded areas of Punjab Doabs. Water samples were collected from the private tubewells of Bari (78), Rechna (69), Chaj (71), Thal (169) Doabs and D.G. Khan Area (32). The collected water samples were analysed, in Water Testing laboratory of SMO. The analysis comprised of pH, EC, Cations, Anions, TDS, SAR and RSC. Analytical results were summarized doab-wise on different water quality parameters. In Bari Doab, 34(44%) water samples were usable, 21(27%) marginal and 23(29%) were hazardous.

In Rechna Doab, 42(61%) water samples were usable, 22(32%) marginal while 5(7%) were hazardous. In Chaj Doab, out of the collected water samples, 42(59%), 23(32%) and 6(9%) were usable, marginal and hazardous respectively. In Thal Doab 119(70%) water samples were usable, 44(26%) marginal while 6(4%) were hazardous. In D.G. Khan, out of the total collected water samples, 5(16%) were usable, 10(31%) marginal and 17(53%) were hazardous.

GEO-CHEMICAL CLASSIFICATION

Major geo-chemical types of groundwater underlain in Bari Doab are $NaHCO_3$ and $Ca(HCO_3)_2$. $NaHCO_3$ and $Mg(HCO_3)_2$ are major geo-chemical types of groundwaters underlain in Rechna Doab. In Chaj Doab, the major groundwaters underlain are $NaHCO_3$ and $Ca(HCO_3)_2$. The major geo-chemical type of groundwaters underlain in Thal Doab and D.G. Khan Area is $Na_2 SO_4$.

Key Words: Groundwater, Usable, Marginal, Hazardous, EC, SAR and RSC

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1. INTRODUCTION

Water is one of the major constraints which limits agricultural production in the country, especially in Barani tract and effective water management is perhaps the biggest challenge to achieve rapid yield increase. The existing surface supplies are quite inadequate not only to meet the crop water requirements but also to bring more area under cultivation. Groundwater resources have played an increasingly important role in

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meeting the country's food and fiber requirements. Groundwater is approximately meeting around 45% of crop water requirements in the country. During the last few years, substantial increase in the number of private tubewells has changed the underground paradigm.

Water level has now declined due to private tubewells development. The impact on groundwater resources is alarming and causes the intrusion of saline water in the fresh zone through lateral or upward movement. Annual groundwater extraction through the tubewells is around 42 MAF while only in Punjab, it is 36 MAF.

2. METHODOLOGY

Keeping in view the problem of water quality in the un-commanded areas, groundwater monitoring program was carried out under Institutionalized Environmental Monitoring (IEM) of Land and Water Conditions under National Drainage Program (NDP) during 2001-04. Scarps Monitoring Organization (SMO) WAPDA conducted the water quality monitoring by sampling of the existing private tubewells in un-commanded areas of Bari, Rechna, Chaj, Thal Doabs and D.G. Khan Area.

The collected water samples were completely analysed in Water Testing laboratory for assessing their quality for pH, EC, Cation, Anion, TDS, SAR and RSC for irrigation purpose. Based on water analysis, the water samples were categorized as Usable, Marginal and Hazardous on the basis of EC, SAR and RSC.

The main objectives of the monitoring program were:

- Collection of necessary data forming sound base for the optimal and safe use of groundwater.
- Delineate fresh and saline groundwater zones.
- Provide necessary water quality data for future planning of groundwater exploitation.

3. RESULTS AND DISCUSSION

Water quality is assessed on the basis of salinity as EC and sodicity as SAR and RSC. Different parametric limits adopted by SMO, WAPDA for categorization of irrigation water are incorporated in Table-1.

Table-1: **Water Quality Criteria**

Water Quality Category	Parametric Limits		
	Salinity as EC (µS/cm) at 25°C	Sodicity as SAR	Sodicity as RSC (meq/l)
Usable	< 1500	<10	< 2.5
Marginal	1500 – 2700	10 -18	2.5 - 5.0

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Hazardous	> 2700	>18	> 5.0

3.1 Groundwater Quality in Bari Doab

The collected data was processed / analysed on the basis of EC, SAR and RSC. In Bari Doab, the number of tubewells alongwith percentage falling in each category was as follows:

Table-2: **Number of Tubewells Falling under Different Water Qualities based on EC, SAR and RSC.**

Name of Doab	No. of T/Wells Sampled	Shallow Groundwater Quality based on EC, SAR and RSC					
		Usable		Marginal		Hazardous	
		Nos.	%age	Nos.	%age	Nos.	%age
Bari Doab	78	34	44	21	27	23	29

The above table indicates that out of 78 tubewells, 34(44%) produced usable, 21(27%) marginal and 23(29%) hazardous water on the basis of all parameters.

In Bari Doab, the water quality of each tubewell on the basis of all parameters was depicted on the map. After contouring, the area was calculated and is reproduced below in Table-3.

Table-3: **Area alongwith percentage falling under different categories based on EC, SAR and RSC in un-commanded Area of Bari Doab.**

(Million Acres)

Name of Doab	G.A	Area falling under different categories based on EC, SAR and RSC					
		Usable		Marginal		Hazardous	
		Area	%age	Area	%age	Area	%age
Bari Doab	0.184	0.080	44	0.050	27	0.054	29

The table reveals that out of 0.184 million acres, 44% was underlain as usable, 27% marginal and 29% hazardous.

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3.2 Geo-Chemical Classification

Geo-Chemical classification was done by Stiff's method. In this method, the dominant radicals from cation and anions (50% or more) are combined together to establish the

geo-chemical types. Some types of waters present in un-commanded area of Bari Doab are given in Table-4.

Table-4: **Number of Tubewells alongwith Percentages falling under Different Geo-Chemical Types in un-commanded Area of Bari Doab.**

Total No. of T/Wells Sampled	Geo-Chemical Types							
	$NaHCO_3$		Na_2So_4		$Ca(HCO_3)_2$		$Mg(HCO_3)_2$	
	No.	%	No.	%	No.	%	No.	%
78	63	81	1	1	13	17	1	1

The above table reveals that majority of the tubewells produced Sodium bicarbonate 63(81%) type of water. The second major category was Calcium bicarbonate 13(17%). The third and forth categories were Sodium sulphate and Magnesium bicarbonate 1(1%) each.

3.3 Groundwater Quality in Rechna Doab

In Rechna Doab, the number of tubewells falling under different categories based on EC, SAR and RSC alongwith percentage are summarized in Table-5

Table-5: **Number of tubewells falling under different categories based on EC, SAR and RSC**

Name of Doab	No. of T/Wells Sampled	Shallow Ground Water Quality based on EC, SAR and RSC					
		Usable		Marginal		Hazardous	
		Nos.	%age	Nos.	%age	Nos.	%age
Rechna Doab	69	42	61	22	32	5	7

The table indicates that out of 69 tubewells, 42(61%) produced usable, 22(32%) marginal while 5(7%) yielded hazardous water.

The water quality of each tubewell was depicted on map. After contouring, the area was calculated as usable, marginal and hazardous and is reported in Table-6.

Table-6: **Area alongwith percentage falling under different categories based on EC, SAR and RSC in un-commanded Area of Rechna Doab.**

(Million Acres)

Name of Doab	G.A.	Area falling under different categories based on EC, SAR and RSC

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		Usable		Marginal		Hazardous	
		Area	%age	Area	%age	Area	%age
Rechna Doab	1.311	0.798	61	0.418	32	0.095	7

The above table reveals that 61% area was underlain by usable, 32% marginal while 7% hazardous water on all parameters basis.

3.4 Geo-Chemical Classification

Under this classification, three types of geo-chemical were present in Rechna Doab which are presented in Table-7.

Table-7: **Number of tubewells alongwith percentage falling under different Geo-Chemical types in un-commanded Area of Rechna Doab.**

No. of T/Wells Sampled	Geo-Chemical Types					
	$NaHCO_3$		$Ca(HCO_3)_2$		$Mg(HCO_3)_2$	
	No.	%	No.	%	No.	%
69	45	65	2	3	22	32

The table shows that most of the tubewells pumped out Sodium bicarbonate waters (65%). The next categories noticed were Magnesium bicarbonate (32%) followed by Calcium bicarbonate (3%).

3.5 Groundwater Quality in Chaj Doab

The analytical results were processed on all parameters basis as usable, marginal and hazardous. The number of tubewells alongwith percentage falling under each category is given below.

Table-8: **Number of tubewells falling under different water quality categories based on EC, SAR and RSC**

Name of Doab	No. of T/Wells Sampled	Shallow Ground Water Quality based on EC, SAR and RSC					
		Usable		Marginal		Hazardous	
		Nos.	%age	Nos.	%age	Nos.	%age
Chaj Doab	71	42	59	23	32	6	9

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The table reveals that out of 71 water samples, 42(59%) yielded usable, 23(32%) marginal and 6(9%) hazardous waters.

The water quality of each tubewell was depicted on the map. After contouring, the area was delineated in usable, marginal and hazardous waters which is produced below in Table-9.

Table-9: **Area alongwith percentage falling under quality categories based on EC, SAR and RSC in un-commanded Area of Chaj Doab**

(Million Acres)

Name of Doab	G.A.	Shallow Ground Water Quality based on EC, SAR and RSC					
		Usable		Marginal		Hazardous	
		Area	%age	Area	%age	Area	%age
Chaj Doab	0.726	0.429	59	0.235	32	0.062	9

The table reveals that out of 0.726 million acres 59% was underlain by usable, 32% marginal and 9% hazardous water.

3.6 Geo-Chemical Classification

Under this classification, four types of geo-chemical types were established in the groundwater and reported in Table-10.

Table-10: **Number of tubewells alongwith percentage falling under different Geo-Chemical types of un-commanded Area in Chaj Doab.**

No. of T/wells Sampled	Geo-Chemical Types							
	$NaHCO_3$		Na_2SO_4		$Ca(HCO_3)_2$		$Mg(HCO_3)_2$	
	No.	%	No.	%	No.	%	No.	%
71	41	58	5	7	15	21	10	14

The table indicates that majority of the tubewells produced Sodium bicarbonate water (58%) followed by Calcium carbonate (21%) and Magnesium bicarbonate (14%) and Sodium sulphate (7%) waters.

3.7 Groundwater Quality in Thal Doab

Groundwater quality based on processed analytical data was summarized on basis EC, SAR and RSC is reported in Table-11.

Table-11: **Number of tubewells falling under different categories based on EC, SAR and RSC.**

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Name of Doab	No. of T/Wells Sampled	Shallow Ground Water Quality based on EC, SAR and RSC					
		Usable		Marginal		Hazardous	
		Nos.	%age	Nos.	%age	Nos.	%age
Thal Doab	169	77	46	41	24	51	30

The table shows that 77(46%) were categorized as usable, 41(24%) marginal and 51(30%) hazardous waters.

The water quality of each tubewell was depicted on the map. After contouring, the area was calculated into usable, marginal and hazardous which is given below in Table-12.

Table-12: **Area alongwith percentage falling under different categories based on EC, SAR and RSC in un-commanded Area of Thal Doab.**

(Million Acres)

Name of Doab	G.A.	Shallow Ground Water Quality based on EC, SAR and RSC					
		Usable		Marginal		Hazardous	
		Area	%age	Area	%age	Area	%age
Thal Doab	3.703	1.687	46	0.898	24	1.118	30

It is evident that 46% area was underlain by usable, 24% marginal and 30% hazardous waters.

3.8 Geo-Chemical Classification

Under this classification, seven types of geo-chemicals were established in the groundwater underlain in the area which is presented below in Table-13.

Table-13: **Number of tubewells alongwith percentage falling under different Geo-Chemical types of un-commanded Area of Thal Doab.**

No. of T/Wells Sampled	Geo-Chemical Types													
	$NaHCO_3$		NaCl		Na_2SO_4		$Ca(HCO_3)_2$		$CaSO_4$		$Mg(HCO_3)_2$		$MgSo_4$	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
169	37	22	28	16	93	55	7	4	1	1	2	1	1	1

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The table indicates that majority of tubewells 93(55%) produced Sodium sulphate, 37(22%) Sodium bicarbonate, 28(16%) Sodium chloride, 7(4%) Calcium carbonate and Calcium sulphate, Magnesium bicarbonate and Magnesium sulphate 1% each geo-chemical type.

3.9 Groundwater Quality in D.G. Khan Area

Groundwater quality in D.G. Khan Area based on EC, SAR and RSC was categorized as usable, marginal and hazardous waters and is reported in Table-14.

Table-14: **Number of samples falling under different water quality categories based on EC, SAR and RSC.**

Source of Water Samples	Total Number Sampled	Shallow Ground Water Quality based on EC, SAR and RSC					
		Usable		Marginal		Hazardous	
		No.	%	No.	%	No.	%
Handpump	19	1	5	5	26	13	69
Tubewell	13	4	31	5	38	4	31
Total	32	5	16	10	31	17	53

The above table reveals that hazardous water was dominant followed by marginal and usable in case of handpumps. In case of tubewells same trend i.e. hazardous water followed by marginal and usable, was followed.

The water quality of each tubewell/ handpump was depicted and after contouring, the area was calculated into usable, marginal and hazardous which is given in Table-15.

Table-15: **Area alongwith percentage falling under different categories based on EC, SAR and RSC in un-commanded Area of D.G. Khan.**

(Million Acres)

Name of Un-commanded Area	Source of Water Samples	G.A.	Shallow Ground Water Quality based on EC, SAR and RSC					
			Usable		Marginal		Hazardous	
			Area	%	Area	%	Area	%
D.G. Khan	Handpump	0.112	0.006	5	0.029	26	0.077	69
	Tubewells	0.076	0.023	30	0.030	40	0.023	30
	Total	0.188	0.029	16	0.059	31	0.100	53

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The table shows that out of the total area, 16%, 31% and 53% was underlain by usable, marginal and hazardous waters respectively.

3.10 Geo-Chemical Classification

Under this classification, 5 types of Geo-chemical were established and reported in Table-16.

Table-16: **Number of handpumps and tubewells alongwith percentage falling under different Geo-Chemical types.**

Source of Water Samples	No. of Samples	Geo-Chemical Types									
		$NaHCO_3$		Na_2SO_4		$CaSO_4$		$Mg(HCO_3)_2$		$MgSO_4$	
		No.	%	No.	%	No.	%	No.	%	No.	%
Handpump	19	-	-	17	89	2	11	-	-	-	-
Tubewell	13	1	7	8	62	2	15	1	8	1	8
Total	32	1	3	25	78	4	13	1	3	1	3

The data reveals that in case of handpumps, two types (Sodium sulphate and Calcium sulphate) and in case of tubewells five types (Sodium sulphate, Calcium sulphate, Magnesium bicarbonate, Sodium bicarbonate and Magnesium sulphate) waters were observed.

CONCLUSIONS

Based on the study conducted by SMO, WAPDA, Lahore following conclusions have been drawn:

BARI DOAB

1. Water Quality based on salinity as well as sodicity as EC, SAR and RSC collectively indicates that usable quality was 44% whereas marginal and hazardous quality are 27% and 29% respectively.

2. Major geo-chemical types of groundwater underlain in the un-commanded area of Bari Doab are Sodium bicarbonate by 81% and Calcium bicarbonate by 19%.

RECHNA DOAB

1. Water Quality based on salinity and sodicity as EC, SAR and RSC reveals that usable quality was dominant by 61%, whereas marginal and hazardous quality was 32% and 7% respectively.

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2. Major geo-chemical types of groundwater underlain in the un-commanded area of Rechna Doab were Sodium bicarbonate by 65% and Magnesium bicarbonate by 32% and Calcium bicarbonate by 3%.

CHAJ DOAB

1. Water quality based on salinity and sodicity as EC, SAR and RSC shows that usable quality was 42(59%), marginal 23(32%) and hazardous 6(9%).

2. Major geo-chemical types of water underlain by the un-commanded area were Sodium bicarbonate and Calcium bicarbonate.

THAL DOAB

1. Water quality based on salinity and sodicity as EC, SAR and RSC indicates that usable quality was dominant by 46% whereas marginal and hazardous quality was 24% and 30% respectively.

2. The groundwater of Thal Doab is mainly affected by salinity and to some extent sodicity also.

D.G. KHAN

1. Water quality based on salinity and sodicity as EC, SAR and RSC shows that usable quality was 16%, marginal 31% and hazardous 53%.

2. Major geo-chemical types of groundwater underlain by the un-commanded area of D.G. Khan was Sodium sulphate by 78%.

3. Like Thal Doab, the groundwater underlain by D.G. Khan Area is associated with high value of salinity.

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Members of Pakistan Delegation along with President ICID, Prof. Dr. Chandra A. Madramootoo, during recognition ceremony for organizers of the 60th International Executive Council (IEC) meeting and 5th Asian Regional Conference (ARC).



President Pakistan Engineering Congress, Engr. Husnain Ahmad making his presentation on his election as Member of **Permanent Committee for Technical Activities (PCTA)**, ICID, at New Delhi, INDIA.

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From 2nd Left : Engr. Syed Mansoob Ali Zaidi, Dr. Muhammad Arshad, Mr. Hassan Javaid Afridi, Mr. Bashir Ahmed Sial and leader of the Pakistan Delegation, Engr. Husnain Ahmad at the 60th International Executive Council (IEC) meeting and 5th Asian Regional Conference.



Pakistan Delegation during the 60th International Executive Council (IEC) meeting and 5th Asian Regional Conference, New Delhi, India.

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President Pakistan Engineering Congress, Engr. Husnain Ahmad sharing his views during a meeting of Working Group on Environment.



Engr. Husnain Ahmad, President, Pakistan Engineering Congress, along with a working group of ICID, during the 60th International Executive Council (IEC) meeting and 5th Asian Regional Conference, New Delhi, India.

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APPLICATION OF FISCAL MEASURES FOR SECURING ACCESS TO SAFE DRINKING WATER- AN ANALYSIS OF COMMUNITY PERCEPTIONS IN ABBOTTABAD DISTRICT

By

Saadullah Ayaz* and Mahmood Akhtar Cheema**

Abstract:
Secure access to water is linked to poverty in many ways, as it affects income and health as well as education, and exacerbating gender disparities and social exclusion. Secure access to safe and reliable drinking water is a key social, health and environmental challenge being faced by inhabitants of Abbottabad. Currently, 88% of Abbottabad's urban population and 62% of rural residents have access to some form of water supply.

An increasing trend in water use is expected to continue resulting in over exploitation of water resources that is resulting in scarcity of available water. The issue is further aggravated because of institutional constraints, declining quality, in- equalities in access and lack of resources and poor governance. Fiscal instruments must be promoted for ensuring sustainable use, prevent infrastructure deterioration, generate revenues for betterment of water supply schemes. Such instruments are also essential for protection of water resources from pollution and management of water utilities and infrastructure in Abbottabad.

This paper presents an analysis of community perceptions regarding application of fiscal measures for improved access to safe drinking water in Abbottabad, district. The results of the study indicate that there is high degree of un- satisfaction with the quality and quantity of available drinking water and people are willing to pay for improved access to safe drinking water in Abbottabad.

Key Words:
Fiscal instruments, drinking water, community perceptions, Abbottabad

Introduction:
The North West Frontier Province (NWFP), where Abbottabad is situated, currently ranks second only to Balochistan as the province with the poorest drinking water supply in the country Abbottabad ranks third in the NWFP in terms of piped water Provision. Currently, 88% of Abbottabad»s urban population and 62% of rural residents have access to some form of water supply, primarily from public stand posts (GoP 2006). But only 32.73% of households have access to drinking water inside the home, while the remaining 67.27% rely on an outdoor source. Findings revealed that overall only 8% of

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households have their own water source. In urban areas, 88% of households depend primarily on government tanks, while 46% of rural households depend on springs and wells (IUCN 2009).

Access to safe and reliable water is a growing concern throughout the district Abbottabad with many areas now facing increasing levels of water pollution and decreased quantity of available water. Like all other basic utilities, the cost of provision of drinking water is the combined result of the management of upstream waterways, large-scale investment in infrastructure, as well as their day-to-day management and maintenance.

Management of water supply systems and infrastructure is a key issue faced by secured access to safe and reliable drinking water in Abbottabad. The fiscal instruments have not been adopted for this sector including; revenue shortfalls, low fees paid by consumers that does not reflect the economic cost of managing and improvement of water supply services, that barely cover 16% of maintenance and repair costs of the available infrastructure (IUCN 2004b: ix).

Currently, only about 92 percent households in urban and 65 percent of household in rural areas on Abbottabad obtain piped supply of water from public sector schemes. While people in these areas pay a very nominal 'service fee' in levy of the supplied water except Nawanshehr Union Council, where users pay 'bill' as per consumption of water from water being supplied through extensive network of supply pipes and overhead storage tanks (IUCN 2004b: ix). Under project being implemented by International Union for Conservation of Nature (IUCN), the tariff revision in being proposed as to cover administrative charges through revised 'progressive block tariff system of water billing' and subsidy to poor households (beneficiaries of Zakat and Bait ul Maal), with a purpose to bring pro- poor fiscal component in sector of drinking water supply.

Application of fiscal measures represents an important way of addressing water issues in the context of secured access, environmental sustainability and better management for available water resource. For Abbottabad, the underlying logic for this is to increase fiscal revenues through water price revision while furthering purposes for resource sustainability, prevent access and promote social and development related dimensions associated with water use.

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Objectives of Study:
The objectives of this study are:

1. To conduct an analysis of the community perceptions regarding application of fiscal instruments for secured access for safe and reliable drinking water in the district Abbottabad,

2. To suggest application of appropriate fiscal measures for improved quality and secured access to drinking water in district Abbottabad.

Material and Methods:

Material: Abbottabad is a city located in the North-West Frontier Province of Pakistan, lying between 34°09′N latitude and 73°13′E longitude being the third-largest city in the province. The city is situated in the Orash Valley, 150 km north of Islamabad and 200 km east of Peshawar at an altitude of 4,120 feet or 1,260 m (Wikipedia 2010).

Abbottabad can be accessed from Karakoram highway which passes through urban centre of the city. Neighboring districts are Mansehra to the north, Muzaffarabad to the east, Haripur to the west and Rawalpindi to the south. The city is bounded at all four sides by the Sarban hills.

Abbottabad's climate is cold during winters and mild during summers with humid temperatures during June and July. During the winter, the temperature may drop to below 0°C and snowfall is common, especially in January. Most rainfall occurs during the monsoon season in summer, stretching from May to August, and can sometimes cause flooding.

According to the 1998 Census, “Hindko” was spoken by 94.26% of the population, followed by “Potohari” at 2.30%, “Pashto” at 2.22% and “Urdu” at 1.05%.[9] Although the first language of most people in Abbottabad is Hindko, Urdu is understood and spoken fluently by majority of the residents and commonly used in the markets, offices and formal functions. English is widely used in business and education.

Methods: A detailed review of literature was carried out before undertaking the research work.. Relevant publications were gathered on similar studies by making use of libraries, relevant web- sites. A detailed survey was conducted in order to assess the community perceptions on application of fiscal instruments on the drinking water sector in Abbottabad through frequent visits and personal interviews with target stakeholders.

The gathered information was analyzed using software tools to present an analysis on the community perception of application of fiscal instruments for securing access to safe drinking water in Abbottabad.

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Results:

Results obtained from the study are presented below:

1. Degree of satisfaction with drinking water quantity and quality

   Response was obtained from people both from rural and urban households regarding degree of satisfaction with available drinking water quantity and quality in district Abbottabad. The results show that among the surveyed respondents, 60 percent of household in urban area showed satisfaction, while in rural household only 36 percent showed satisfaction with the quantity and quality of available drinking water. These results are graphically shown in Figure 1.

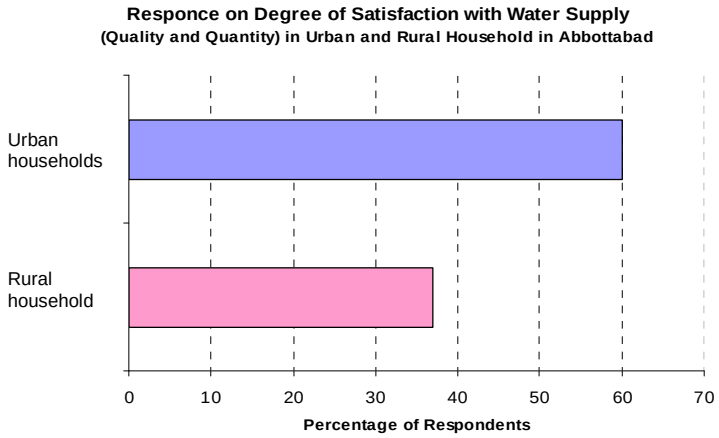


Figure 1.

2. Key Priority among respondents regarding supplied water

During the survey, response was obtained from residents both from rural and urban households regarding parameters/ key priorities for quantity and quality of water in district Abbottabad. The results show that among the surveyed respondents, “regular supply” of water was identified as key priority by 34 percent of urban and 50 percent of rural household. Similarly, “convenience” for obtaining water was identified as a priority by 20 percent of rural and 4 percent of urban household. Meanwhile, ”improved quality’ of water was identified as key priority by 34 percent of urban and 40 percent of rural household. These results are graphically shown in Figure 2. below:

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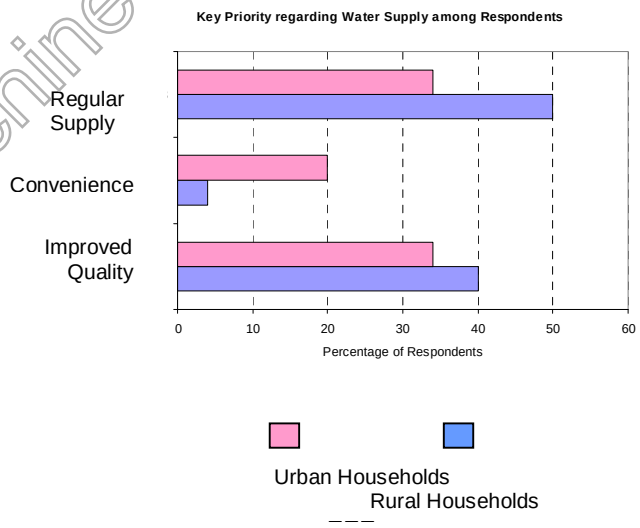


Figure 2.

3. Willingness to pay for improved access to safe drinking water

During the survey, response was obtained from residents both from rural and urban households regarding willingness to pay for improved access to safe drinking water in district Abbottabad. The results show that among the surveyed respondents, 9 percent of rural and 3 percent of urban household are ready to pay between Rs. 1- 50 per month. Similarly, 19 percent of urban residents and 55 percent of residents of rural areas are willing to pay between Rs. 50- 100 per month. Meanwhile, 24 percent of rural residents and 49 urban residents of Abbottabad district are willing to pay higher than Rs. 100 per month for improved access o safe drinking water. These results are graphically shown in Figure 3. below:

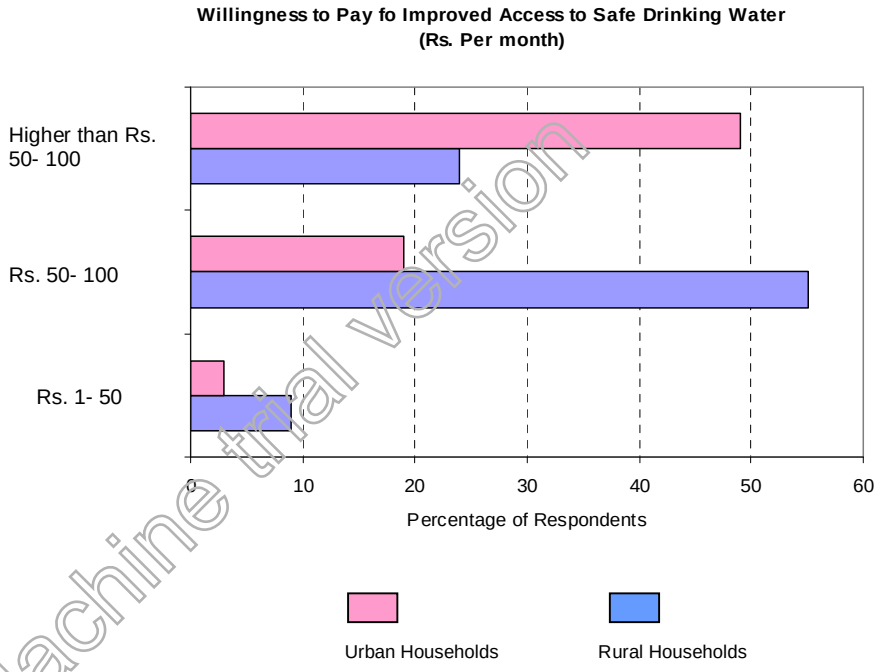


Figure 3.

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Discussions and Recommendations:

The results of the study show a clear view that most of the people are not satisfied with the quality and quantity of drinking water being supplied. A clear difference can be seen in rural and urban household shown that the respondents from urban area show a higher degree of satisfaction (60 percent), probably due to better quality and quantity of water

being supplied. This also shows that the services of drinking water supply are not as good as in rural areas (36 percent) of Abbottabad district

Similarly, the results regarding parameters/ key priorities for quantity and quality of water in district Abbottabad show that "regular supply" has been highlighted as priority by rural residents in higher number (50 percent) as compared to resident of urban areas (34 percent). These results also show that "convenience" for obtaining water is a higher priority for urban residents showing a marked higher percentage, due to higher water demands in urban areas, where as only 4 percent of rural resident consider it a priority. While, "improved quality' of drinking water is also considered a priority almost equally by urban and rural residents showing that the quality of drinking water is equally considered a priority in these areas.

Based on the results of this study, the following recommendations are made for application of fiscal instruments to secure access to drinking water in Abbottabad district:

1. In light of depleting quality and reduced quantity of drinking water, there is a need to apply fiscal measures for improving access to both urban and rural residents of Abbottabad. Such measure could be regular billing system for drinking water supply, higher tariffs and user charges.

2. Since people are willing to pay for secured access to drinking water, application of proper fiscal instruments will be beneficial for improvement of services, through better system management, infrastructure development and resource management.

3. Application of proper fiscal instruments can serve as a mean for taxation that can contribute to exchequer and also will help in resource development and environmental conservation.

4. Pro- poor fiscal measure needs to be initiated like subsidy or exemption for poor of Abbottabad district (beneficiaries of Zakat and Bait ul Maal). The margin for such investments could be met for implementation of "progressive block tariff system' in which users to be charged as per progressive use of water and separate tariff for commercial users.

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GROUNDWATER MANAGEMENT AND RECHARGE POTENTIAL AS AN ALTERNATE TO MEGA SURFACE STORAGES

By

Muhammad Basharat[1] and Danial Hashmi[2]

ABSTRACT

Pakistan is an agrarian country where irrigation is used on 75 % of agricultural land, mainly in Indus Basin. There is much variability in river flows and crop water requirement round the year, surface water reservoirs were constructed under Indus Basin replacement works to reduce temporal gap between water availability and requirement. However, the long halt in surface storage development in the country since the completion of Tarbela reservoir in 1976 and silting up of storages therein with passage of time has diverted increasing demand for canal water towards groundwater development. The alluvial aquifer that underlies the Indus Basin Irrigation System (IBIS) had unintentionally stored huge quantities of water (about 40 ft rise) after inception of irrigation system within about 40-50 years time. This huge storage has provided a big boom for increasing cropping intensities, but it has surpassed the safe limits of groundwater use and sustainability of existing agriculture is at alarming risk. Currently this storage is being depleted at a rate of about 1.2 ft/year in many of the areas, which means it will not last longer.

There is therefore a dire need to rehabilitate the groundwater potential of the Indus basin in the form of underground storage of surplus surface water. Analysis of below Kotri escapages for 1976-2008 shows that 31.47 MAF annually is escaping below Kotri Barrage. Exceedance chance is 87.1 % for 6.55 MAF proposed for groundwater recharge in Punjab and below Kotri releases to check sea intrusion for four months. Maintaining river flows in dry reaches for 4 months have groundwater recharge potential of about 5.35 MAF in Punjab in addition to suppressing below Kotri seawater intrusion in Sind. Additional benefits will further accommodate the needs of fisheries and environmental sustainability in river channels.

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1. INTRODUCTION

The world's fresh water resources are unequally distributed both in time and space. Until recently water resource management focused on reallocating river water to demand centers i.e. when and where it was required, a supply-side or fragmented approach. Nowadays there are signs that water resource availability is dwindling – due to both population growth and increased per capita water use – and ecosystems are being damaged. To face this challenge, new holistic approaches well matched with local challenges are being devised and implemented in most of the countries all over the world. This approach includes the integrated or conjunctive use of surface and groundwater resources at system level. It takes account of social, economic and environmental factors along with the importance of water quality issues within the system.

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Indus Basin Irrigation System (IBIS) encompasses arid to semiarid climate and annual canal diversions are less as compared to evapotranspiration. It was originally based on the objective of irrigating the maximum area possible. The system was designed for an annual cropping intensity of about 75 percent with the intention to spread the irrigation water over as large an area as possible to expand the settlement opportunities (Jurriens and Mollinga, 1996). Now the increasing demand for food to cope with the ever increasing population has caused the annual cropping intensities to rise to 150 to 180 percent in different canal commands. This has become possible only with increasing contribution of groundwater for meeting additional water requirement, but has resulted in increased concentration of salts in groundwater. This change in groundwater environment needs to be tackled on scientific and long term basis rather than short term perspective otherwise the situation may not be reversible. A study undertaken in 1990 (NESPAK/SGI 1991) pointed out that in Punjab the volume of groundwater extracted significantly exceeds the volume of water recharged. The study estimates the difference to be as much as 27 % on a provincial basis, but this overexploitation is concentrated in a number of fresh groundwater areas. This is in line with that as reported by Steenbergen and Oliemans (1997), that the share of groundwater in the supply of irrigation water has been rising from 8 % to 40 % from 1960 to 1985. Also Halcrow (2006) reported that the groundwater use by farmers has increased from 8% in 1960 to 60% at the start of 21st century.

Current rate of over exploitation of groundwater can be very devastating to the environment and economic well being of the populace of the area. Current trends has induced water level drawdown to the levels where existing depths of wells do not support pumping and re-drilling of majority of wells is being implemented by the farmers in many depleted groundwater areas of IBIS. This has increased the investment of farmers and will not serve the purpose in the long run. If the present trend of groundwater depletion continues, after few years there will be need of lowering the wells again and change of pumping technologies from centrifugal to submersible, thus increasing the cost of investment and pumping to many folds. The time is fast approaching that groundwater may become out of reach of small/poor farmers. According to PPSGDP (2000) the areas with deeper groundwater levels generally are located in tail reaches of the canal system. This increasing depth to groundwater across the commands has caused considerably decreasing net income of farmers in head to tail direction as reported by Latif and Ahmad (2009).

In the absence of additional surface storages, groundwater recharge and management is a viable choice as it is already contributing about half of the crop water requirements. Unfortunately there is no concerted effort to manage this precious resource. The government agencies are only concerned with management of canal water. There exists no systematic groundwater investigation, evaluation and development plan accompanied with monitoring so as to keep an eye on the possible overdraft and deterioration of the resource. The institutional or strategic level groundwater management does not exist at all. This has created a wide gap between a planned, regulated, scientific and sustainable use of groundwater resources and current practice of mushrooming of tubewells as shown in figure 1. Therefore, a technically feasible, socially acceptable and economically

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viable groundwater management system concentrating both aspects i.e. groundwater governance and recharge is the need of the day.

During preceding many decades (1960s – 1990s) surplus water was available in the Indus River System, but exceptionally low quantity is available during the current decade as shown in figure 2. The preceding many decades, therefore presented a condition where canal water was available in excess to the crop water requirements due to low cropping intensities. This generated a situation where recharge component from seepage surpassed the abstraction from groundwater and as a result groundwater levels rose to near to ground surface. As the cropping intensities increased and drought conditions prevailed for many years, crop water requirements were met through pumping of groundwater. This steadily induced declining trends in depth to watertable (DTW) as is currently being observed since many years resulting not only in the elimination of waterlogging but now groundwater depletion is a fact in most of our canal commands. The danger in current scenario is over pumping causing groundwater mining and secondary salinity caused due to poor quality of groundwater. The major aim of our irrigation system management should be to keep an eye on this issue and chalk out strategic plan assuring sustainability of our groundwater irrigation.

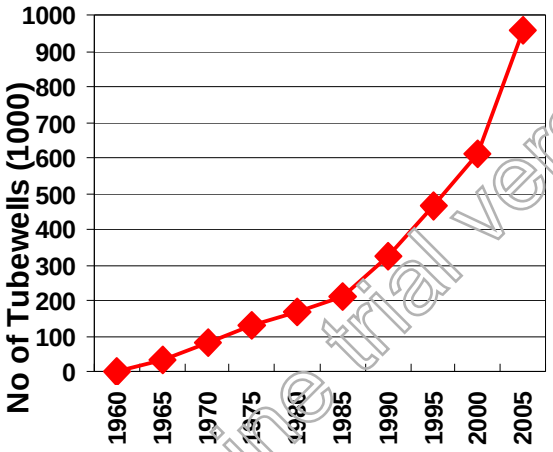


Figure 1: Growth of private tubewells in Pakistan.

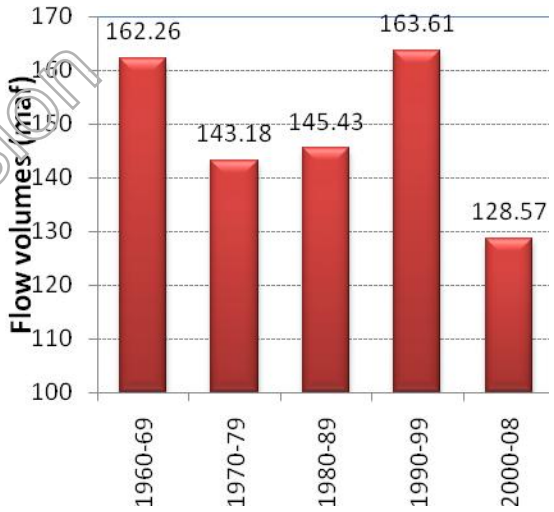


Figure 2: Annual average (10 yearly) flows in Indus River System.

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1.1 Degradation of River and Groundwater Environment

Groundwater depletion should also be looked into as an environmental concern because it provides a cushion for meeting crop water requirement in drought periods which are cyclic in nature. So, water resource management should also focus to preserve or enhance the groundwater environment's buffering capacity to withstand unexpected stress or negative long-term trends in the form of droughts. As the environment's carrying capacity is put under increasing pressure, due to the growing needs of the population and over use of its resources, environmental vulnerability has increased too.

Also the degradation of our river environment is increasing day by day. Several river reaches of the order of hundreds of kilometers has become municipal waste carriers. In this context, mismanagement of water resources, not paying any attention to the environment but only lip service to irrigation needs particularly in Rabi season, has led to water scarcity and water pollution which is threatening security and the quality of human life. Giving proper regard to this unsustainable trend, the need is to acknowledge the pivotal role that integrated water resource management can play in the process of sustainable water resources management. This new approach must take into account of social, economic and environmental factors and comprehend surface water, groundwater and the ecosystems through which they flow.

Among the ADB member countries, Pakistan has the highest rate of utilization of the total available freshwater resources at 61%. In terms of groundwater withdrawal, Pakistan's annual rate of 489.5 m^3 per capita is also the highest by a wide margin (Raymond and Husaini 2006). This information clearly indicates (i) the high reliance that Pakistan has on its available water resources for irrigation and (ii) the importance of increasing the efficiency of water use when there is limited scope for increasing the supply due to internal political division between the provinces for construction of dams for storage. The above diminution coupled with degradation of water resources base of IBIS is also leading to environmental hazards in all the four provinces particularly the Punjab and Sind. So the selection of most appropriate development and management options on strategic lines needs to be the principal planning concern.

1.2 Irrigation and Groundwater Development

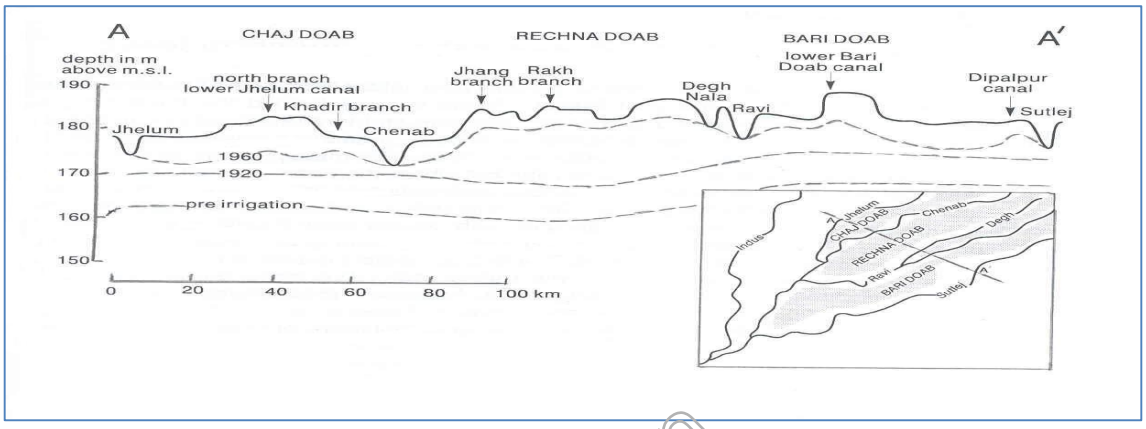
After the introduction of weir-controlled irrigation in 1871 (Ahmed 1993), the groundwater table started rising due to poor irrigation management, lack of drainage facilities and the resulting additional recharge from the canals, distributaries, minors, water courses and irrigation fields. On the other hand, the extensive use of groundwater for irrigation started with the installation of public tubewells in 1960's, followed by the explosive development of tubewell installation by private farmers (about one million at present and still growing at annual rate of 1-2%). The total groundwater extraction from private tubewells for Punjab has been estimated to be 43.4 BCM (35 MAF) for 2002 (Qureshi and Akhtar 2002), whereas, average canal diversions (1977-82) to Punjab were 54.4 MAF. Where as, on Pakistan basis, the annual groundwater abstraction under the latest drought conditions (1999-2002) has been estimated to be about 55 MAF. This high groundwater use in recent decades shows that farmers are only left with the groundwater development choice for coping with any increased water demand due to increasing cropping intensity and other competing uses such as domestic and industrial as a result of population increase.

1.3 Changing aquifer behaviour over one century

Before the introduction of widespread irrigation, the groundwater table in the Indus Basin varied from about 40 feet in depth, in Sindh and Bahawalpur areas, to about 100 feet, in Rechna Doab. Seepage from irrigation systems, some of which have been in operation for more than 150 years, was the principal cause of rise in water levels. Geologic studies have shown that virtually the entire Punjab is underlain to depths of 1000 ft or more by unconsolidated alluvium, which was saturated to within a few feet of land surface due to seepage as shown in figure 3 (Greenman et al. 1967). The alluvium complex consists

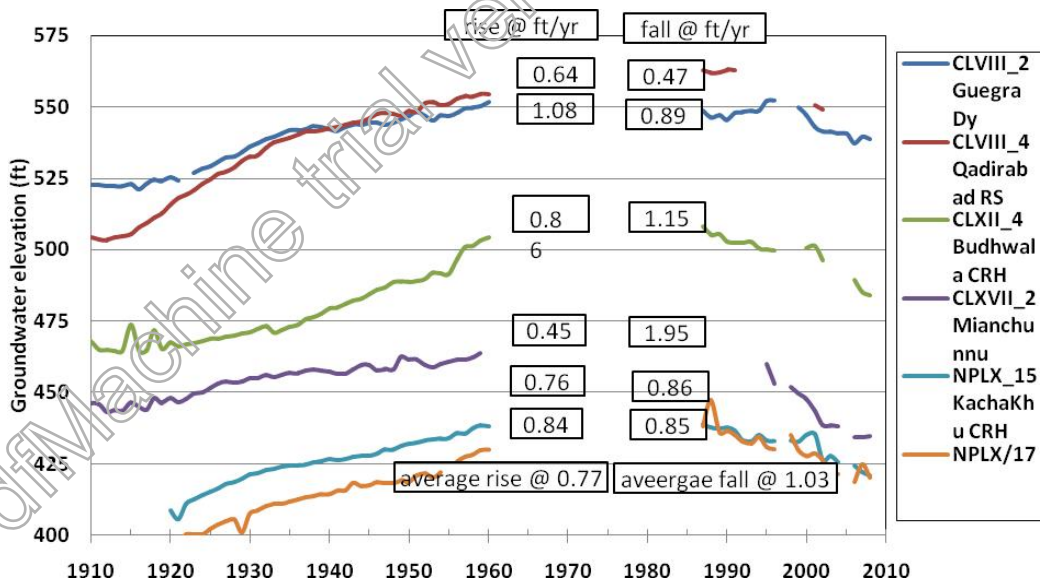
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principally of fine to medium sand, silt and clay. In the natural environment that existed before the inception of perennial canal irrigation, the groundwater hydraulic system was in dynamic equilibrium i.e. recharge to groundwater reservoir almost balanced discharge and there was no long term rise or fall of the watertable as shown in figure 4 by early parts (1910-14) of groundwater level hydrographs for Lower Bari Doab Canal (LBDC) area. Groundwater was derived from under flow from the upstream areas and from local precipitation. Evidently underflow form upstream and recharge from precipitation did not quite balance underflow downstream and evapotranspiration losses; so equilibrium was maintained by small component of recharge from the rivers to groundwater reservoir as



shown by pre-irrigation groundwater regime in figure 3.

Figure 3: History of Groundwater rise in Punjab (Source Greenman et al., 1967.)



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Figure 4: Groundwater hydrographs spanned over one century, showing reservoir filling and depletion in LBDC command.

The superposition of canal system introduced additional factors of recharge which resulted in rise of watertable in and around irrigated areas. As reported by Greenman et al. (1967) the average rate of groundwater rise was 2.2, 2.07, 2.0 and 1.1 ft per year for Rechna, Chaj, Thal and central Bari Doabs respectively. For the Lower Bari Doab, rate of groundwater rise has been reported as 0.7 ft per year. As seepage from the irrigation systems caused the watertable to rise, the hydraulic gradients in the vicinity of rivers gradually lessened and the seepage losses from the rivers also decreased due to reduced river flows as a result of canal diversions.

When the watertable reached approximate equilibrium, seepage into the aquifer from the irrigation network was either lost to evapotranspiration or taken into storage and released gradually to rivers and drains built during 1960's and 1970's. In addition to building drains their was a concerted effort to "eliminate" these issues by installing Government sponsored dual purpose tubewells i.e. functioning both for irrigation and drainage.

Originally the surface water system was designed for a relatively low irrigation intensity of about 60 to 70 %. As reported by Ahmad (1993), cropping intensity was 102.8, 110.5 and 121.7 % during 1960, 1972 and 1980 respectively. Thus as a result of population growth, cropping intensity has been steadily rising, and now operating at over 150%. While some of this increase has come from stretching the surface water system the majority has come from increased use of groundwater with tubewells numbers touching to the tune of one million in Pakistan. Now, Pakistan has transitioned over the last 30 years to become heavily reliant on groundwater to supplement the surface water supplies. There is no regulation of either the installation of tubewells or the amount that can be extracted from them. Now the groundwater levels are again going deeper and deeper. That means the underground reservoir that was recharged by newly built irrigation system with low cropping intensities (about 60-70%), is now being overexploited due to increased cropping intensity.

The groundwater levels in the aquifer has risen much with passage of time in response to spreading of irrigation supplies starting about one century earlier, and then lowered as a result of burgeoning groundwater withdrawals. These changes in aquifer levels encompassing over one century are shown in figure 4 for individual observations for LBDC command. The interval for 1961 to 1986 is a gap due to non availability of the data. Rate of groundwater rise has also been shown for the individual observation wells. The average rate of groundwater rise was 0.77 ft per year for these seven hydrographs. Whereas on the other hand a totally reverse behavior is there for the period starting from 1987 to 2008 indicating a watertable decline even at much faster rate than it rose to the surface as result of irrigation development in the area. This is actually due to the population pressure in terms of increased groundwater use for domestic, industrial and agricultural purposes. During this period of 21 years, groundwater depletion to the tune of 21 ft has taken place particularly in tail reaches of LBDC command. When compared

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to the situation of maximum groundwater rise of 1960s, excessive pumping of groundwater for irrigation and other uses has caused water-level declines of greater than 50 and 100 feet in irrigated areas and under the big municipalities respectively.

1.4 Research Thrust and Development

Keeping in view the current situation of water availability and use particularly the increasing groundwater development over the safe yield, research needs to be focused more effectively than in the past on planning and management problems of conjunctive use of surface and groundwater in the country. This is the main way forward to provide planners and decision makers with suitable and well-optimized solutions for targeted measures designed to enhance conjunctive use efficiency, while protecting the environment. Lack of research and application of research findings is considered as one of the main reasons for the problems plaguing the water sector i.e. low efficiency, environmental degradation, high costs and lack of beneficiary responsiveness.

Current international trend in aquifer management focuses on determining the maximum and minimum water levels, in order to regulate groundwater storage capacity. Whereas the situation in Pakistan is concerned, uncontrolled overexploitation causing progressive drawdown, has lead to increased pumping costs, infiltration of poor quality water, lateral saline intrusion, drying up of wet lands and shallow wells, and possible up-coning of salts. Moreover, in coastal aquifers the prolonged reduction of freshwater flow towards the sea reduces the equilibrium gradient, inducing seawater intrusion through backflow of seawater in the Indus and disturbing the inland freshwater–saltwater interface. Combining so many aspects requires methods of analysis that systematically integrate them in such a way that within the planning process alternative solutions can be defined, tested and chosen.

In an effort to counter the falling watertables India's Central Groundwater Board developed a national blueprint for groundwater recharge in the country which aims at recharging surplus runoff of about 36.4 billion cubic meters (29.5 MAF) in an area of about 450,000 sq km identified in various parts of the country experiencing a sharp decline in groundwater levels Villholth (2006). This required investing in creating scientific capability and infrastructure for groundwater recharge as a top priority for regions with excessive pumpage and significant renewable water resources. But in case of IBIS, the major hindrance to groundwater recharge is availability of surface water, the scenario of which has been totally changed after implementation of Indus Basin Treaty between India and Pakistan in 1960. The result is that many of the river reaches remain dry for most of the time and excess flow is only available during monsoon season. So the real issue is how to manage our river flows particularly for groundwater recharge in integration to existing surface reservoirs. Whereas, now a days prevailing opinion about possibility of groundwater recharge from rainfall runoff is not going to add any considerable amount in irrigated areas, because of already increased local recharge from the rainfall due to watertable depletion.

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2. GROUNDWATER DEPLETION CONSEQUENCES

Although the nation has fully harnessed the available groundwater potential, which was developed not during centuries but over a period of about fifty years just after inception

of new irrigation development as is the case for LBDC command (commissioned in 1913), i.e. period during which the aquifer got fully recharged. It is anticipated that the present growth rate of using groundwater is not sustainable for much longer period. The groundwater data analysis shows that the ill effects of using the aquifers beyond safe yield limits are emerging with passage of time. Groundwater depletion is now a fact and its consequences are emerging in the form of quality deterioration and increased costs of groundwater development and pumping. Groundwater depletion is also important in coastal areas, where lowering of the watertable induces salt-water intrusion into water supplies either directly from sea side or from river side due to back seawater flow during no/low River Indus flows.

2.1 Increasing Groundwater Development

Current situation and practices regarding groundwater development is manifested in the exponential growth of tubewells within last three decades. Particularly, the increased cropping intensity in agriculture sector is responsible for major depletion of groundwater mostly in fresh groundwater areas. To highlight this increased use of groundwater by the agriculture sector, groundwater pumping in LBDC command has been compared. The reported number of tubewells in Lower Bari Doab Canal (LBDC) command in 1994-95 was about 20,000 with annual groundwater abstraction of 2710 MCM (NESPAK-NDC-AHT, 1995). The tubewell numbers in LBDC then exploded to about 48,000 in 2005 (NESPAK, 2005). Total groundwater pumping for agriculture purposes over the LBDC command has been estimated afresh as 3394 MCM based on 2005 data. Thus within a period of 10 years 684 MCM increase in groundwater usage per annum has been found in LBDC command. This indicates 2.3 % annual increase in groundwater pumping which is comparable with that of population growth rate of 2.1%. That means population growth resulting in increased water demand in the form of increasing cropping intensities is mainly responsible for unprecedented groundwater depletion along with other factors e.g. recent drought conditions. The resulting decline in groundwater level has been computed for the period 1987 to 2008 as shown in Table 1, based on the data of 79 observation wells falling in Sahiwal and Khanewal Divisions of LBDC command. The data also covers the drought period with the highest depletion rate of 1.74 ft per year. On an average for Sahiwal and Khanewal Divisions of LBDC command the rate of groundwater depletion is 1.2 ft/year for the period 1987 to 2008. The volume of groundwater depleted in these two irrigation divisions for the above period, using 15% specific yield is 4.68 MAF (GCA 1.48 million acres).

Table 1: Change in Depth To Watertable (DTW) per year over different periods in irrigation Divisions of LBDC.

LBDC Division	1987 to 1996		1998 to 2002 (drought)		2005 to 2008	
	# of observation Wells	decline (ft)	# of observation Wells	decline (ft)	# of observation Wells	Decline (ft)
Sahiwal	7	0.52	6	1.74	43	0.59
Khanewal	3	0.62	6	1.74	36	1.16

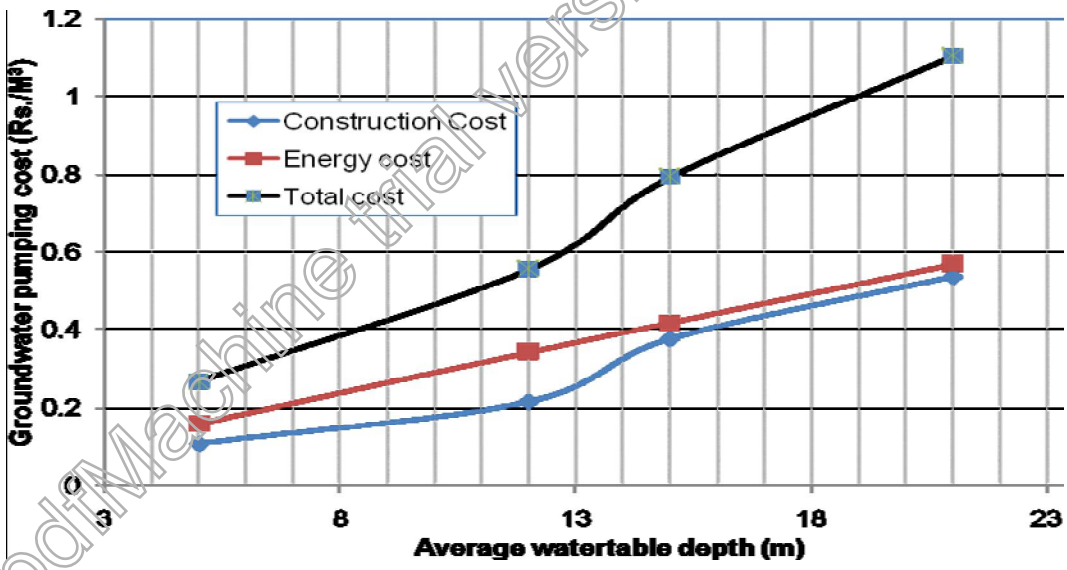
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2.2 Lateral Pollution

Given that the aquifer system prior to broad scale irrigation was in equilibrium with outflow control by the rivers as the hydraulic boundaries. The brackish waters were generally captured in the middle of the alluvial doabs between the rivers. Other geological features also influenced the location. As the aquifer system was filled as a result of irrigation all the aquifers rose to be close to the surface. This caused the broad scale waterlogging and salinity of the 60's and 70's. Now we are faced with aquifers that are falling as a result of the one million tubewells installed in the fresh water zones to supplement irrigation. As water is only being pumped from the freshwater zones, this may had already set up the conditions for lateral movement. The danger from this saline intrusion has been reported frequently but still needs to be proved with actual field data evaluated specifically.

2.3 Impacts on Poorer Farmers

As the groundwater drops, the cost of pumping increases. If it falls much further then the need arises to change technologies from centrifugal pumps to the more expensive turbine pumps. The cost imposes a significant burden on the small farmer who do not normally have sufficient cash flow to accommodate such changes. Cost of groundwater pumping with increase in depth to watertable has been estimated from data of drilling depth and pumping equipment commonly used across the LBDC command (Halcrow 2006). It is apparent that cost per cubic meter of groundwater pumped increases about 3.5 times as the depth to watertable drops from 6 to 21 m from head to tail in LBDC command as shown in figure 5.



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Figure 5: Increase in cost of groundwater pumping with decline in watertable.

3. WATER STORAGE

In conjunctive use, the two most important issues that planners have to face concern the storage of surplus water and the optimal allocation of water withdrawals. With regard to the first problem, a question that needs to be answered is where to store water and which reservoirs to develop: surface or subsurface?

3.1 Subsurface Storage, Merits & Demerits

The advantages of subsurface over surface reservoirs are:

- surface reservoirs are lost forever once they are silted up, while underground storage capacities remain practically unaffected by development;
- yields from groundwater storage, less affected by evaporation and leakage, are more dependable than yields from surface reservoirs;
- subsurface storage is achievable without loss of water-spread areas thus no need for relocation of the local population;
- groundwater can be put to use where and when it is required, with less risk of seepage or evaporation losses during storage and transmission;
- there is less ecological hazard compared to surface storage projects;
- the cost of storing groundwater is less than that of surface storage and;
- there is no risk of surface flooding in the form of dam breaks in case exceptionally high floods develop in the system.

In spite of many advantages over surface storage, there are some constraints also, such as:

- groundwater storage withdrawal is a highly energy intensive process, while surface water is often available by gravity flow;
- surface reservoirs are more suitable for multiple uses e.g. energy production and recreation;
- mineralization is generally lower in surface water storage.

4. GROUNDWATER MANAGEMENT

For sustainable development of water resources in IBIS, it is imperative to make a quantitative estimation of the available water resources. First task would be to make a realistic assessment of the surface water and groundwater resources and then plan their use in such a way that full crop water requirements are met and there is neither waterlogging nor excessive lowering of groundwater table. It is necessary to maintain the groundwater reservoir in a state of dynamic equilibrium over a period of time encompassing wet and drought years. So that water level fluctuations are kept within a particular range, thus making it possible for utilizing groundwater storage developed during wet years to be used during drought years. It is proposed that classification of areas under different depths to watertable (DTW) may be based as suggested in table 2. This will help to delineate areas where artificial recharge is needed urgently. Last column of the table, proposes how to tackle the groundwater depletion on DTW basis.

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Table 2: Proposed classification of areas under different depths to watertable

Sr. #	DTW (ft)		Proposed classification	Revising Water allocations
1	0	5	Waterlogged	Allowance to be decreased

2	5	10	Likely to be waterlogged	No change
3	10	30	Normal	No change
4	30	45	Likely to be depleted	Extra water allowance during monsoon
5	45	60	Depleted	Permanent extra water allowance
6	More than 60		Highly depleted	Creation of permanent lakes in addition to extra water allowance

Recharge to groundwater by creating artificial lakes in areas with depth to watertable more than 60 feet needs to be permanent feature of irrigation system. These proposed lakes called command level surface/groundwater storage of flood supplies, can be filled during flood season on the basis of flood share of each canal command. It is likely that these areas are away from possible sources of recharge to groundwater such as main canals and barrages, mostly these area lie at tail ends of the canal commands falling within the centers of doabs. This will require proper water balance/groundwater modeling studies regarding surface water allocations and its impact in raising the watertable in surrounding areas. Areas will have to be selected based upon;

- Depth to watertable and remoteness from recharge sources such as rivers and canals.
- Areas with high infiltration rates and adjoining deep watertable.
- Proper water allowance during floods depending upon intensity of flood flows in respective areas. Also some extra/minimum allocation during each monsoon season.

4.1 Recharge Potential

It is well established that our aquifers are depleting and on average (1976-2008) there is 31.5 MAF surplus water going below the Kotri Barrage without any intended regulation for seawater intrusion and other needs such as environmental flows in dry river reaches mostly in Punjab. So there is need to quantify both the requirement for groundwater recharge i.e. the recharge potential of our aquifers and the surface water which can be allocated for the purpose without disrupting the existing uses. As 70 % of the 21.6 Mac of irrigated area in Punjab having fresh groundwater, is already supplementing canal

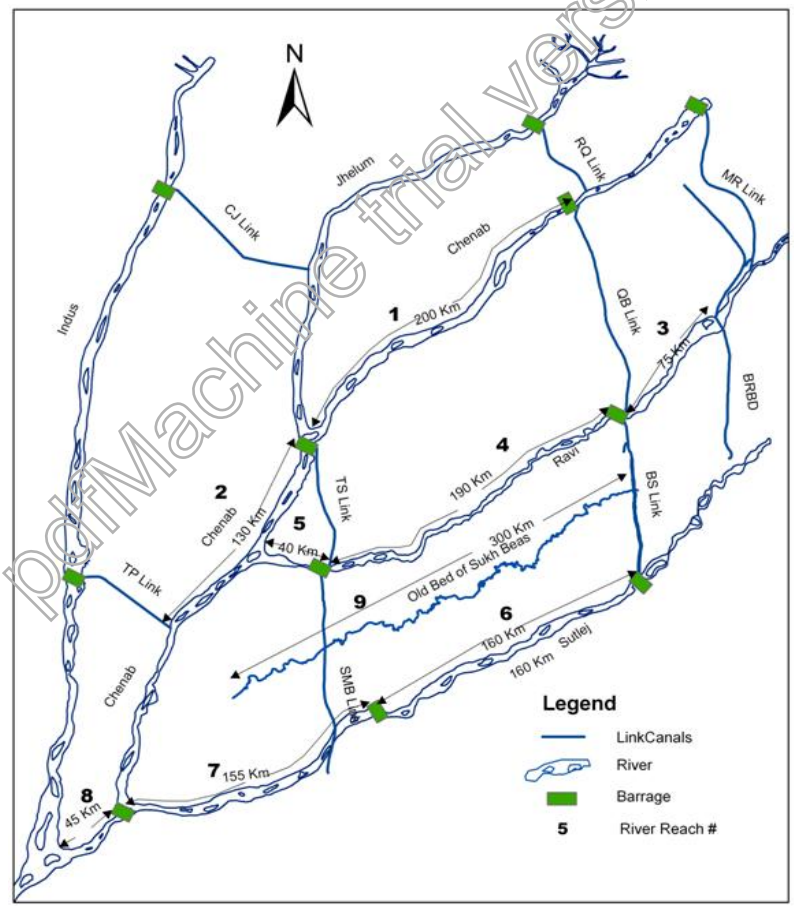


Figure 6: River reaches proposed for groundwater recharge.

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water supplies by depletion of groundwater storage and current recharge from the irrigation system. It is assumed that out of this fresh zone, 50 % area i.e. 7.5 Mac can be used to fill the upper 30 ft of the aquifer. With 15% storage coefficient, the possibility of water storage in the above area comes out to be 33.75 MAF. This groundwater storage if properly managed in integration with surface water resources can serve on cyclic basis for as long a period as are the droughts which are cyclic in nature. Purpose built infrastructure building/remodeling of existing canals where needed, for water conveyance to depleted areas will be required on priority basis.

4.2 River Management

All the rivers in Punjab are connected through inter river link canals for conveying water to the canals under the command of eastern rivers. At present, river water management is being implemented with the objectives of meeting demands of agriculture ignoring even the environmental flow requirements of rivers. In this regard Kamal (2008) has recommended environmental flows allocation of the Indus, Jhelum, Chenab, Ravi and Sutlej as 2.25 and 6 MAF for Rabi and Kharif seasons respectively. In Indus river system, it is only during floods that certain reaches receive water (figure 6, marked with length and reach #). Total length of rivers lying with out water during non flood season is about 995 km, all of them lying in Punjab. Assuming 500 m river width under water spreading during minimum flows and seepage rate of about 4 cfs/msf, the total wetted perimeter contributing towards seepage to the underground is 5516 million square feet. Thus total seepage rate from these river reaches comes out to be 22,065 cusecs. Using reservoir storage in such a way that this discharge is allowed to flow for four months will add about 5.35 MAF to aquifers along the rivers. The old bed of Sukh-Beas lying in the center of Bari doab i.e. the area with maximum groundwater depletion can offer maximum aquifer storage potential. The flood water can be diverted to Sukh-Beas via the B.S. link where the escape structure already exists. Adding 0.3 MAF required to check below Kotri seawater intrusion as recommended by MWH-ACE-NESPAK (2005), total releases required for the purpose for a period of four months are 6.55 MAF as given in Table 3.

Table 3: Proposed discharges and volumes calculated for 4 months, within different reaches of river system assuming 500 m as river perimeter contributing to seepage @ 4 cfs/msf.

Reach #	River Reach		Wetted perimeter (msf)	Discharge (cfs)	Volume (MAF)
	start-end	Length (Km)			
1	Qadirabad to Trimu	200	1076.36	4305.46	1.04
2	Trimu to TP Link	130	699.64	2798.55	0.68
3	Ravi up to Balloki	75	403.64	1614.55	0.39
4	Balloki to Sidhnai	190	1022.55	4090.19	0.99
5	Sidhnai down to Chenab river	40	215.27	861.09	0.21
6	Sulemanki to Islam	160	861.09	3444.37	0.83
7	Islam to Punjnad	155	834.18	3336.73	0.81
8	Punjnad to Indus	45	242.18	968.73	0.23
9	Old Sukh Beas	300	161.45[1]	645.82	0.16
10	Below Kotri	-	-	5000[2]	1.20

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Total	1295	5516.37	27065.48	6.55

5. RIVER FLOWS

Scarcity of water for irrigated agriculture and high temporal and spatial variability of flows in the Indus river system demands very careful analysis of the river flows for decision making purpose. The pattern of flows at Kotri Barrage is affected by the canal withdrawals at upstream barrages and storage by the reservoirs in addition to inflows at the rim stations. Over 80 % of inflows to the Indus river system occurs, on average, during two flood months of July and August (MWH ACE NESPAK 2005). The 1991 Water Accord primarily determined the river water apportionment among the four provinces of Pakistan. It also comprised the share of provinces in the surplus discharges flowing in the rivers as floods. The IRSA apportions the Indus River System flows through two large and one small reservoir, 19 barrages and 45 major canal systems. In the absence of any additional storages in the system, it is proposed to manage the excess flows by diverting through dry river reaches for groundwater recharge and environmental flows for Punjab and releases to check seawater intrusion and environmental flows below Kotri Barrage for Sind. For the purpose it is suggested to divert the proposed flows for four months (before and during flood season) in the dry river reaches in lieu of expected excess flows in the system.

Annual river flows going below Kotri Barrage (figure 7) has been analyzed for the post Tarbela (76-77 to 2008-09) period. Still on an average there is spillage of about 31.47 MAF annually to the sea. The long term downstream average flows below the Kotri Barrage has been calculated as given in table 4. The yearly escapages below Kotri Barrage were ranked and % chance of exceedance for these values was calculated. The resulting values are plotted in the form of graph as shown in figure 8. For the proposed releases of 6.55 MAF from the existing storages before the monsoon season as environmental/groundwater recharge flows, the chance that during succeeding monsoon season their will be excess available in the system are 87.13%. This shows that the proposed releases can be managed with 12.86% probability of water shortage due to these releases in advance. However chances of this shortage can be further reduced by improved prediction of river flows for Kabul and Indus rivers and acting accordingly.

Table 4: Longterm average flows, downstream Kotri Barrage (MAF).

Period	Pre-Kotri	Post-Kotri	Post-Tarbela
	1937 to 1954	1955 to 1975	1976 to 2008
Kharif	71.656	56.455	29.6
Rabi	8.862	5.862	1.87
Annual	80.52	62.32	31.47

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1. For Sukh Beas, wetted perimeter has been assumed 50 m, which can be developed by weirs at appropriate intervals along the length of the river course.
2. For Below Kotri 5000 cfs is based on recommendations made in the Kotri Study-I (2005) as the required minimum flow.

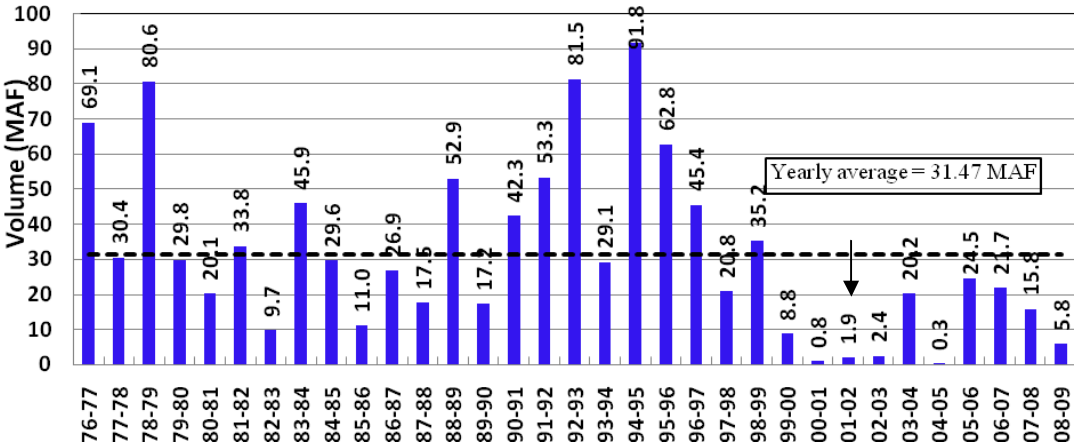


Figure 7: Escapages below Kotri Barrage for post Tarbela period (1976-77 to 2008-09).

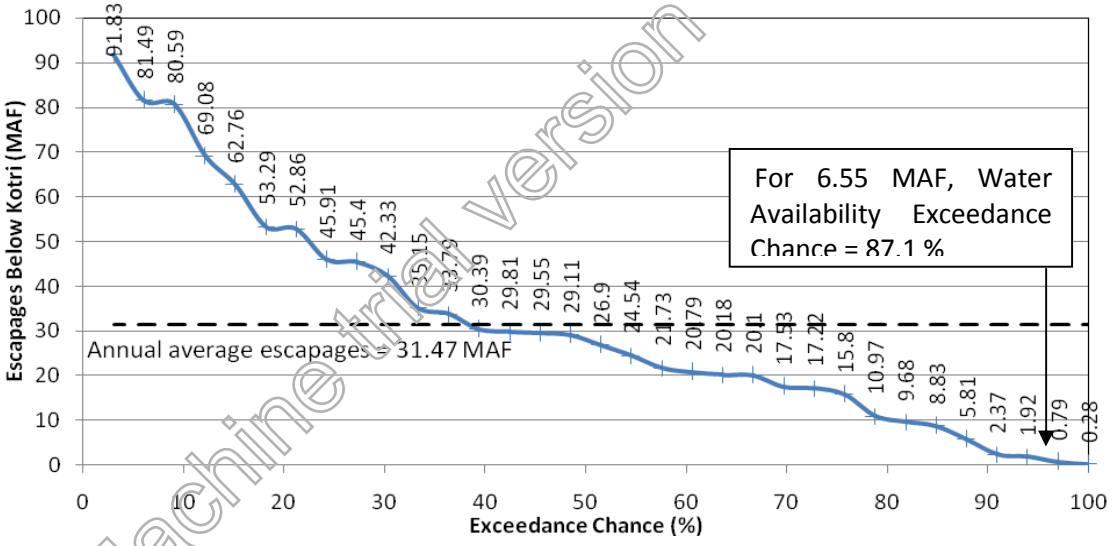


Figure 8: Historical escapages below Kotri with corresponding exceedance chances.

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5.1 Climate Change Impact on Future Water Availability

Although the science of Climate Change is still in infancy, there are reports that, it is going to effect the melting of Western Himalaya glaciers. It is reported, that in early few decades of twenty first century, there will be excessive glacier melt of Karakoram Glaciers and flows of River Indus at Besham Qila will be increased by about 50 percent,

and thereafter there will be terrifying reduction in flows and they will be reduced to about 40 percent of Year 2000 value by the end of the century (Rees and Collins, 2004). Climatology section of Global Change Impact Study Centre has worked out by ensemble the results of six Global Circulation Models for this area. The reasonable temperature increase for whole century seems to be 0.035 °C/year. This increase, according to Rees and Collins, 2004), will yield additional flows of the order of 5.2 MAF annually for the second decade of the century then there will be steady decline of 22 MAF in Besham Qila flows in coming 80 years. There must be some storage readily available to store this surplus water.

Similarly Climate Change is going to affect the South Asian Monsoon. It is reported in International Panel on Climate Change Third Assessment Report that the results of nine out of ten Global Circulation Models results show that there will be increase of the order of 8-24% in South Asian Monsoons. This additional water will be variable and intense in space and time and can be readily stored in fresh ground water aquifer of Punjab, preferable in eastern and south eastern doabs.

6. RECHARGE MANAGEMENT OPTIONS

Presently there is no plan and even lack of thinking prevails towards groundwater management and recharge of precious aquifers lying under the IBIS, which at present contribute to the tune of 50% of crop water requirements. This contribution of groundwater is without any management by any government body, at national or provincial levels, so sustainability of this 50% crop water supply is very much doubtful. As discussed, 31.47 MAF of water is currently escaping to sea without any management of seawater intrusion or groundwater recharge in Punjab. Anticipated climate change is also expected to cause increase in river flows by about 50 % and thereafter probably a terrifying reduction is also expected. So keeping in view the existing scenario and expected climate change impacts, the need of managing surface and groundwater conjunctively cannot be over emphasized. The fruits of this much needed approach cannot be enjoyed till a considerable experience and confidence is gained with passage of time. Following are the course of options which can be adopted step wise to harness full potential of IBIS;

- Business as usual and wait for the groundwater to become an opportunity for the rich farmers only.
- Start groundwater augmentation by diverting surplus water in old bed of Sukh Beas as a pilot project during flood season. This requires little further planning and investment because the proposed site is already connected to river Ravi via BS Link.
- Start planning for reserving and using part of Mangla storage which can be released for recharge through river reaches connected through the link canals or otherwise.
- Similarly start the same feasibility process for planning to use part of Tarbela storage and Kabul river flows as groundwater recharge releases before the monsoon season.
- Develop a comprehensive feasibility for groundwater recharge and regular releases below Kotri barrage to check seawater intrusion by utilizing the prevailing escapages below Kotri within the provisions of 1991 water accord.

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7. CONCLUSIONS

Diversion of surplus surface water to groundwater storage appears to offer the most favorable prospects for controlling below Kotri escapages of our precious resource in the absence of any surface storages to be added in future. The alluvial aquifer that underlies the Punjab is ideal for the purpose in nearly all respects. It is favorably situated with respect to both availability of water for recharge and to areas of use of water, and there are no extensive geologic barriers to recharge or to circulation within the aquifer. The storage capacity of groundwater reservoir is equal to many times the annual flow of the Indus River system. The question is how to manage this big reservoir. Moreover the groundwater reservoir has infinite life because the groundwater storage is free of sediments. Thus it is concluded that the use of groundwater storage would permit more flexible and complete control of water resources of the Indus Basin. The groundwater reservoir can be replenished according to the availability of surface water for recharge and the reservoir can be tapped according to the demand for water with out regard to seasonal or annual variations in river flows.

The major problem involved in the management of the aquifers as a reservoir is that of promoting artificial recharge at a sufficient rate to accommodate surplus surface supplies during the period of high river flows. Although the problem is formidable but this needs further insight and search to be implemented step by step until all the surplus river supplies are allocated. All of these matters must be carefully studied before the most desirable plan for resource development and utilization can be taken up. Specific conclusions are:

- Tapping the recharge potential of our aquifers can provide a reliable buffer to cyclical or annual shortages of surface supplies; recharge during wet years and extraction during dry years can limit the impact of cyclical droughts.
- A huge groundwater recharge potential exists in the aquifers due to their depletion beyond optimum limits.
- New and emerging uses of groundwater e.g. small water supply schemes along fresh water resources such as rivers and canals will have substantial impact in future on already under stress groundwater areas particularly with respect to quality deterioration of the resource with passage of time.

8. RECOMMENDATIONS

Groundwater is a basic resource for humans and natural ecosystems and is one of the nation's most important natural resources. Keeping in view the rate of groundwater depletion and availability of surplus river flows in the system during wet season, following are the recommendations.

- There has been wastage of excess water to Sea during wet years to the tune of 31.47 MAF annually. After subtracting 10 MAF below Kotri requirements for checking seawater intrusion, still there is potential of 21.47 MAF on an annual average to be effectively controlled through multi-purpose storages. Part of this can also be utilized

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as groundwater recharge/environmental flows even without any big investment at this very initial stage.

- Proper sites can be developed in groundwater depletion areas of each canal command for command level surface/groundwater storage during wet years for groundwater recharge.
- Environmental flows can be managed for dry river reaches lying in Punjab by ensuring certain flows for few months during non monsoon season. As a next step, structures can be built at appropriate sites for flooding of flood plains along the rivers.
- Diverting flood waters through nalas and abandoned river beds such as the old bed of Beas River in Bari Doab can be very easily managed by allocating certain amount of river water for the purpose.
- For scientific based water resources management in IBIS, modeling of river system needs to be undertaken. This can answer many of the issues regarding water resources management.
- Criteria of depth to watertable classification in irrigated areas needs to be revised to include areas under stress with respect to groundwater availability as proposed in table 2.
- A feasibility study is recommended to highlight the prospects of groundwater recharge for enhancing the IBIS productivity. At large scale this would lead to creating scientific capability and investment for building infrastructure for groundwater recharge.

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Pakistan Engineering Congress
Symposium on Genesis of Power Crisis and its Management in Pakistan Held in July – 2009 at PC Hotel Lahore – A Report

A Symposium was arranged by Pakistan Engineering Congress on Genesis of Power Crisis and its Management in Pakistan in July, 2009. The Honorable Syed Khurshid Ahmad Shah Federal Minister for Labour and Man Power was the Chief Guest.

The Welcome Address was delivered by Engr. Husnain Ahmad, President, Pakistan Engineering Congress by expressing his view point that energy is the life line of economic development but unfortunately Pakistan lacks integrated National Energy Security Plan for the 21st century and, therefore, the country is faced with a crippling power shortage to the tune of almost 1890 MW. The peak demand is around 19600 MW vis-à-vis supply of 17710 MW necessitating Electricity outages of 10-12 hours daily. Non-availability of power and the frequent interruptions have wreaked the economic fabric of the country culminating in :

(1) De-stabilized the entire economic structure of the country.

(2) Given a stunning blow to Agriculture sector for acute shortage of water supply and non-availability of power for tubewells.

(3) Industrial production has suffered enormous set-back. Textile, Garment and host of other industries are at a stand still.

(4) Un-employment Conditions have further worsened exacerbating law and order problems etc.

(5) Large Scale Manufacturing (LSM) has shown 7.7% negative growth.

(6) GDP growth is sliding down (2%).

As the demand of electricity was accelerating at an annual rate of 8-10%. 21500 MW of electricity will be required by 2010. President Pakistan Engineering Congress suggested that :

(1) Experts should plan a “Capacity” Generation increase of 3000 to 4000 M.W energy per year which would need long term planning on pragmatic basis.

(2) Pakistan ought to go all-out for construction of Mega Dams for conservation of water and generation of cheap electricity.

(3) The maximum utilization of coal resources as well as to leap-frog in the domain of Nuclear energy.

(4) Build big refineries.

(5) Maximum utilization of bio-fuels “Wind Energy” and “Solar Energy”.

(6) All out efforts to conserve energy.

(7) Import of Gas from Iran and Central Asian Countries.

(8) Private Sector Foreign Investment may be invited.

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The Chief Guest Syed Khursheed Ahmad Shah said power generation capacity of the country will be increased by 3,000 MW by December 2009 and 13,000 MW by 2012. The minister said the government had also signed agreements to generate 5,000 MW power from Thar Coal with two foreign companies. Work had been started for generation of 2,000 MW. The coal reserves would last for more than 2,000 years, he added. He said those who criticized the government for awarding thermal power generation contracts to IPPs had failed to point-out the then Govt's. failure to utilize the enormous coal reserves. The government had agreed to purchase thermal power from the IPPs at 6.5 cents per unit which was equal to Rs. 2.40 per unit at that time and was not excessive. The present power crisis had been created because the past regimes did not increase the power generation capacity of the country even by a single MW during its eight year tenure, he added.



Engr. Husnain Ahmad President Pakistan Engineering Congress delivering Welcome Address at the Symposium.



From Left: Syed Khursheed Ahmad Shah, Chief Guest,
Engr. Husnain Ahmad, President Pakistan Engineering Congress

In view of the overriding problems of the current energy crunch, the following 10-papers were presented at the Symposium.

1. Role of Hydropower in Management of Power Crisis in Pakistan
   by Dr. Izhar-ul-Haq and Engr. Khawar Munir.

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From Left: Engr. Ch. Ghulam Hussain Vice-President/Secretary PEC,
Syed Khursheed Ahmad Shah Chief Guest, Engr. Husnain Ahmad,
President Pakistan Engineering Congress,
Engr. Rana Khursheed Anver,
Vice-President / Convener Symposium Committee

2. Introduction of New Technologies for Renewable and Demand Side Management in the Power Sector in Pakistan
   by Prof. Dr. Zahir Ahmad Fikri.

3. Genesis of Power Crisis and Its Management in Pakistan
   by Amjad Agha.

4. Power Crisis, Causes and Management
   by Engr. Riaz Ahsan Baig

5. Self Generation to Combat Power Crisis
   by Dr. Engr. Javed Younas Uppal.

6. Public Private Partnership to Mitigate Power Crisis
   by Dr. Allah Bakhsh Sufi, Zahid Hussain Khan and Muhammad Javaid Iqbal.

7. Genesis of Power Crisis and Its Management in Pakistan
   by Engr. Tahir Basharat Cheema.

8. Natural Gas Transmission and Distribution Infrastructure Development in Pakistan and Its Role in Power Generation
   by A. Rashid Lone.

9. Barriers in Renewable Energy Deployment in Pakistan
   by Syed Tahawar Hussain.

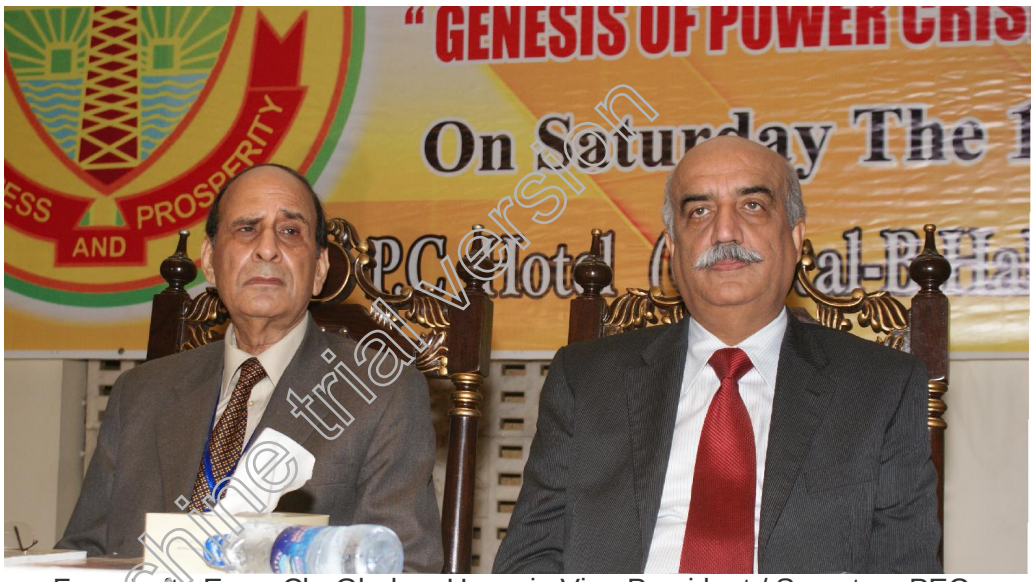
10. Renewable Energies – An Ultimate Solution to Overcome Power Crisis of Pakistan
    by Muhammad Ammad Riaz, Sana Amin.

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Glimpses of the Event



Engr. Husnain Ahmad, President Pakistan Engineering Congress
Presenting the Shield to the Chief Guest Syed Khursheed Ahmad Shah,
Federal Minister for Labour and Manpower



From Left : Engr. Ch. Ghulam Hussain Vice-President / Secretary PEC,
Syed Khursheed Ahmad Shah Chief Guest



Federal Minister Syed Khursheed Ahmad Shah delivering his in-augural address

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Glimpses of the Event



Dr. Izhar-ul-Haq Vice-President, Pakistan Engineering Congress presenting his paper





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Glimpses of the Event







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After the Symposium a panel of experts deliberated the issues involved and after an in-depth study, formulated the following recommendations for Combating the Power Crisis. These have been submitted for implementation to the concerned Provincial and Federal Government authorities at the highest level (duly acknowledged by them and forwarded to the relevant quarters).

RECOMMENDATIONS FOR SOLUTION OF ENERGY DEFICIT

Pakistan has a hydro-potential of around 54000 MW of which only 6464 MW have been exploited to-date. Looking at the fast pace of development, Pakistan requires at least 20,000 MW during next decade. A number of projects are under various stages of studies and investigations. Hydro-power being the least expensive source of energy is environmentally clean and renewable. If cheap power is not added to the system, it would become unaffordable rendering Pakistan Industry non-competitive and untenable in the world market.

Injection of cheap Hydro-Power through construction of multipurpose dams with effective participation of private sector is crucial. Some of the multipurpose dams needing hot chase are; Diamer Basha, Kalabagh, Dasu, Akhori, Kurrum Tangi and Munda.

For short term – Power conservation and reduction in losses must be addressed immediately. Country is facing a loss of about 29 billion units per year which is 25% of the power produced. The losses have a substantial pilferage element.

Also WAPDA owned thermal plants have become very inefficient. These should be upgraded with combined cycle technology. This action alone would liberate 1000 MW – 1500 MW for the system.

Thermal power generation through imported oil is exhorbitantly expensive and spirals the electric prices.

The policy orientation has to be drastically modified.

We have gigantic coal reserves of 184 billion tons lying untapped in Sind and Baluchistan. Coal mining has to be given top priority for power generation through indigenous coal. This has to be developed on fast track.

Gas, another indigenous resource – A number of new gas fields discovered have not yet been operated. Such fields should be fully developed at top speed. New explorations should be encouraged.

At the same time execution of Iran – Pakistan gas pipeline should be undertaken on fast track basis while negotiations be held with other Central Asian States to explore the possibility of cheaper gas without loosing further time. Shortfall in gas supply is directly affecting our power generation and industrial uses. Conservation should be encouraged. Import of LNG should also be promoted.

In addition nuclear energy field has to be exploited for augmenting the power supply. Efforts should be made to set-up greater number and larger atomic plants preferably with China's help who are already manufacturing 900 MW atomic units.

Self-Generation Co-Generation in industry : – To come out of present difficult situation, it is proposed to resort to self-generation within communities with the assistance of GOP. Participative mechanisms need to be formed in which power production is done at community level, particularly in rural areas. Following projects fit the rural energy model for participating and decentralized energy production on small scales which may be more economical than extending the central grid station. Communities play a key role in selecting, purchasing and operating their own system.

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- Micro hydro-power generation.
- Bio-Mass power generation, Bio-Gas plants and garbage power.
- Solar Photovoltaic Cells, Solar home solutions, Solar powered cookers, water heaters, solar water pumping, Solar street lighting system.etc
- Micro-wing power generators.

Pakistan Council of renewable energy technologies (PCRET) has already implemented micro-hydro-power schemes in FATA and Agha Khan rural support program, constructed 171 Micro-Hydel units in Northern Areas.

Wind energy potential which is available in the range of 15000 MW should be exploited at a faster rate.

Demand side management and conservation measures have to be addressed at domestic and industrial sectors. Power conservation and reduction in losses is another important area which GOP should give priority, by encouraging use of more energy savers, installation of capacitors on distribution feeders to improve power factor, and rehabilitation of distribution feeders to reduce line losses. Units saved are far more economical than units generated.

Incentives and financial support upto 50% may be provided to encourage receivables and demand side management. These programs be implemented at Provincial and Federal Level.

Last but not the least, professional bodies like Pakistan Engineering Congress should be fostered to play a significant role through dissemination of know-how, training and technological support.

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